

Chapter Twenty-one

TOOLS AND EQUIPMENT

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A COMPLETE LIST of the tools and equipment required to carry out complete engine overhaul, and servicing between overhaul, of all types of de Havilland Gas Turbines is contained in a separate publication issued by The Service Department of The de Havilland Engine Company. This separate publication lists the tools and equipment necessary under three main headings: Tools and equipment for servicing between overhaul; tools and equipment for complete overhaul; and test bed equipment.

THIS CHAPTER contains instructions, where considered necessary, for servicing, adjusting, or calibrating the tools and equipment, including the test bench, which are used in connection with the Ghost 48 Mk. 1; the servicing tools are listed on pages 15 to 19. Where it is considered that an operator could economically make certain tools or items of equipment himself, suitably dimensioned illustrations will be included in this chapter.

CALIBRATION OF INSTRUMENTS

The instrument calibrating equipment referred to in the following chapter is identical to that used by the engine manufacturers. Extensive experience with various types of equipment has been gained, and whilst it is appreciated that it may not always be possible for operators to employ identical equipment and that there are similar types available that will serve the purpose very well, the

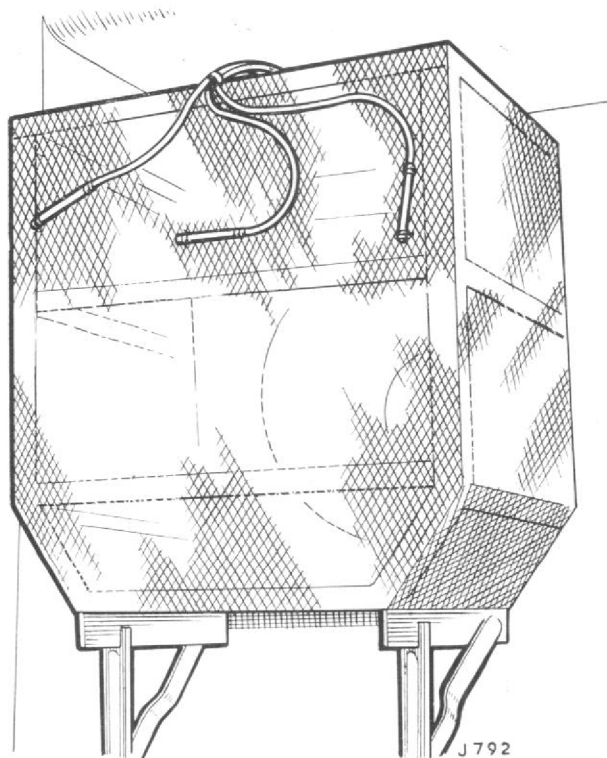


Fig. 1. Typical example of the location of temperature bulbs on air-intake guard.

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equipment recommended and methods applied are considered to be the most satisfactory.

registered on the indicator dial, and the instrument is ready for calibrating.

AIR INTAKE TEMPERATURE EQUIPMENT

That part of the air intake temperature equipment requiring to be calibrated consists of three resistance bulbs, connected in series to a Cambridge Ratiometer type temperature indicator, having a calibrated range of from minus 10 deg. C. to + 100 deg. C. The resistance bulbs are normally located on the air-intake guard approximately in the positions shown in Fig. 1, and the indicator is situated on the instrument panel.

It should be clearly understood that the correct positioning of the temperature bulbs on the air-intake guard will have been decided during the initial calibration of the test bench, following its erection. It is important that the three bulbs do actually record a true mean air intake temperature, and their final location will have been decided after a careful study of the air-flow characteristics of the air-intake, as affected by the particular design of test cell and air-intake surround.

For the purpose of calibrating the equipment, an oil bath is required, the dimensions of which should be not less than 8 in. $\times$ 8 in. $\times$ 12 in. deep. A suitable heating element upon which the bath is placed is used to raise the temperature of the oil. To maintain the temperature of the oil as constant as possible throughout its entire bulk, it should be stirred continuously during the actual calibration; a small hand drill brace fitted with a spade tipped or similarly shaped attachment serves the purpose very well. A mercury in glass thermometer of certified accuracy is also required.

Before calibrating, the datum setting of the indicator must be checked and adjusted as necessary. On the front cover of the instrument will be found two adjusting screws, inscribed RHEO and ZERO respectively, with a three-position switch adjacent. With the instrument connected up in readiness for the calibration as shown in Fig. 2, the switch on the instrument cover should be turned to the OFF position. By means of the adjusting screw marked ZERO, position the needle of the indicator so that it lines up with the red OFF line inscribed on the instrument dial. Next turn the three-position switch to the TEST position and by means of the adjusting screw marked RHEO position the indicator needle so that it lines up with the red line marked TEST at the upper end of the indicator scale. With the switch turned to the ON position, the ambient temperature of the thermocouple, checked by comparison with a mercury in glass thermometer, should now be

The calibrating procedure is as follows:—Fill the container with hydraulic oil to specification D.T.D.44D, or, if this is not available, with thin engine oil, to within about an inch of the top. Place the container on the heating element and, after connecting the resistance bulbs in series to the temperature indicator, suspend them in such a manner that the entire element portions of the

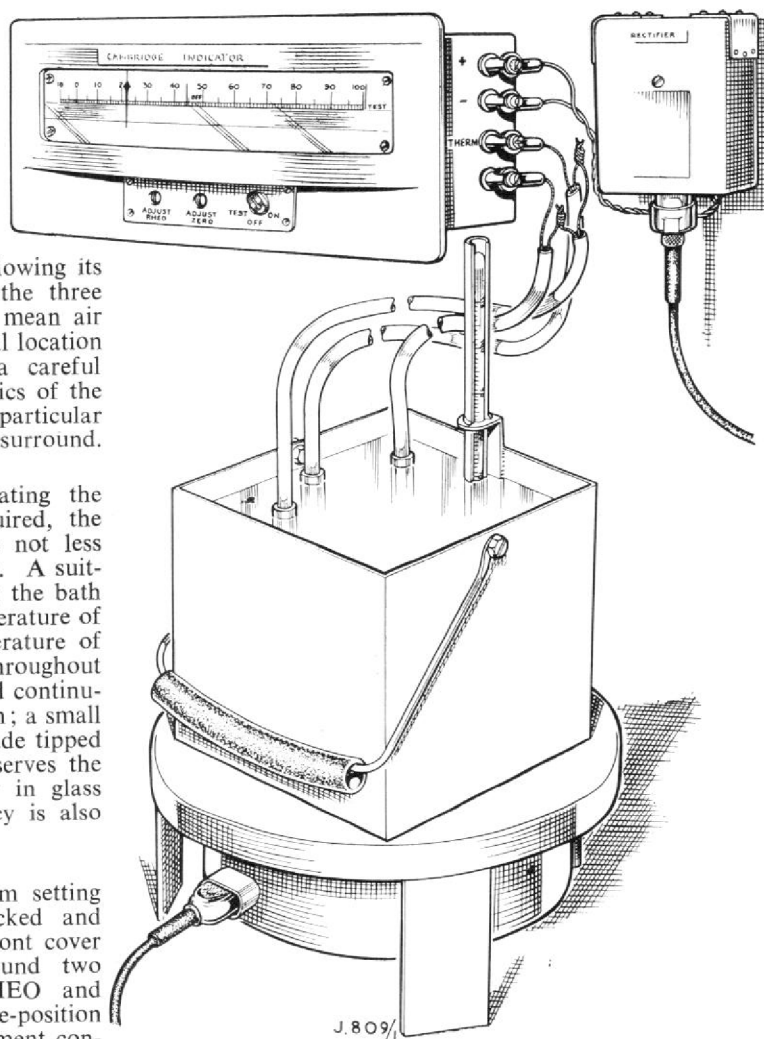


Fig. 2. Oil bath in readiness for calibration of air intake temperature equipment; and details of Cambridge type indicator.

bulbs are immersed in the oil. Suitably suspend the mercury in glass thermometer in the oil, making sure that it does not touch the bottom of the container, and switch on the heating element.

The temperature is then raised steadily, and the liquid constantly stirred whilst comparative readings are taken of the temperature indicator and the thermometer every 10 deg. C. over a range defined by local climatic conditions. A comparison of the readings obtained from the indicator

with those registered on the thermometer will disclose any error in the instrument. The permissible error tolerance is $\pm \frac{1}{2}$ deg. C., at any reading over the entire working range.

After completing the oil-bath calibration, remove the resistance bulbs and wipe thoroughly before refitting them to the air intake guard.

OIL TEMPERATURE EQUIPMENT

The portion of the oil temperature equipment that requires calibrating consists of one resistance bulb, type S.84, connected to a Ratiometer type temperature indicator, having a calibrated range of from minus 10 deg. C. to + 100 deg. C. The normal location of the resistance bulb is a pocket situated in the top accessory box as shown in Fig. 3, and the indicator is situated on the instrument panel.

Before the equipment is calibrated the temperature indicator should be subjected to the same datum setting check as that outlined for the air intake temperature indicator.

The same calibrating rig can be used for the oil temperature bulb and indicator as is used for checking the air intake temperature equipment. The procedure is identical, but the permissible error tolerance in this case is ± 1 deg. C.

REAR BEARING TEMPERATURE EQUIPMENT

It will be necessary to calibrate the following rear bearing temperature equipment:—One 10-inch

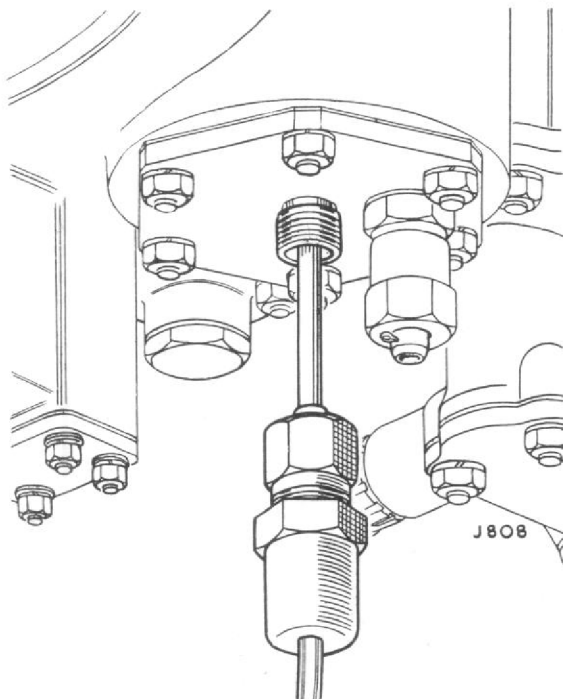


Fig. 3. Oil temperature bulb being inserted into pocket in oil pressure filter.

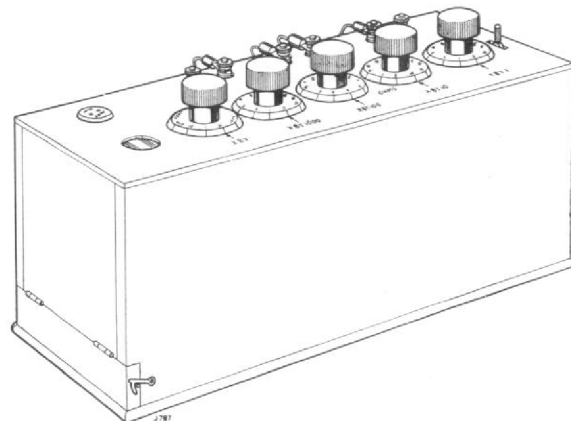


Fig. 4. Wheatstone bridge.

edgewise scale indicator, having a scale range of from 0 to 300 deg. C. A copper and constantan compensating lead, 30 ft. long, coloured white, with green positive tracer and blue negative. The thermocouple for the rear bearing is an integral part of the engine.

It is of paramount importance that the length of the compensating lead for this, and any other instrument where a compensating lead is employed, should not be altered. Calibration of the instrument is based on the external resistance of a fixed length of compensating lead, and any alteration of the length will render the instrument completely inaccurate.

The terminal block connecting the thermocouple to the compensating lead must not be subjected to a temperature exceeding 60 deg. C. Care must be taken therefore in determining its location.

The insulation and continuity check is carried out after ensuring that the hot junction, i.e., the attachment which is located at the rear bearing, is at a temperature comparable with the prevailing test cell temperature. An engine which has been running must, therefore, be allowed to cool, until the above requirements are met, before proceeding with the calibration. It is, therefore, recommended that wherever possible a slave rear bearing thermocouple should be used for this calibration.

Before commencing, the temperature indicator pointer must be set to the ambient temperature of the instrument, by means of the square headed adjusting screw on top of the case, and with the leads to the instrument disconnected. The temperature of the control room being ascertained by means of a mercury in glass thermometer of certified accuracy.

Connect the thermocouple to the compensating lead by means of the terminal block, ensuring that positive (copper) is connected to positive, and negative (constantan) to negative. Connect the other end of the compensating lead to a Wheatstone bridge (Fig. 4), whereupon the total resist-

ance can be measured. The correct external resistance of 2.65 ohms will be found inscribed on the dial of the indicator, in the bottom right-hand corner, and the resistance figure obtained on the Wheatstone bridge dial should compare with that inscribed on the dial of the indicator, to within ± 0.050 ohms.

To calibrate the temperature indicator, a potentiometer (Fig. 5) is connected in series in the instrument circuit, by disconnecting the negative terminal tab of the compensating lead, at the cold junction end, and connecting it to one of the terminals of the potentiometer. An extra run of single core lead of suitable length and gauge, having a resistance of not more than 0.02 ohms, is then connected between the cold junction negative terminal and the second terminal on the potentiometer. Adjacent to the plus and minus terminals on the potentiometer will be found a thermometer. This will register the ambient temperature of the cold junction and the potentiometer must be initially set to this reading by means of the left-hand control marked "cold junction". By depressing the button K1, the out of balance of the potentiometer can be ascertained from the balance dial and corrected by manipulation of the control marked "Rheostat".

With a complete circuit now re-established, and the potentiometer in balance, the calibration setting dial is initially set to 50 deg. C. by means of the right-hand control. Depression of the balance indicator button marked K2 on the poten-

tiometer will permit the out of balance to be established, and it is then possible to restore the balance by manipulation of the resistance control on the potential divider. Once this has been effected, reference should be made to the temperature recording instrument, which should now register 50 deg. C. Any deviation from this figure will constitute instrument error, and should be recorded. The potentiometer dial should now be re-set to 100 deg. C. and the balancing and recording procedure repeated. A third point should then be checked at 150 deg. C. and finally at 200 deg. C., after which the calibration is complete.

The maximum deviation permissible at any point throughout the check is ± 2 deg. C

JET-PIPE TEMPERATURE EQUIPMENT

The jet-pipe temperature equipment that requires calibrating consists of:—four chromel and alumel thermocouples; four compensating leads coloured white, with green positive and blue negative tracers; and four 10-inch edgewise scale indicators, each having a temperature scale range of from 0 deg. C. to 1000 deg. C. The specified external resistance of the thermocouple and compensating lead is 5.9 ohms ± 0.05 ohms.

The calibration of this type of equipment is divided into three parts.

1. Resistance check for testing the continuity of the circuit and checking the external resistance against the specified figure.
2. Potentiometer check, for proving the accuracy of the temperature recording instrument.
3. "Freeze check" for proving the functional accuracy of the thermocouple at 419.5 deg. C. ("Freeze point" is the temperature at which molten metal solidifies, 419.5 deg. C. being the "Freeze point" of anular zinc.)

The resistance check is conducted with the same equipment, and in the identical manner to that described for the rear bearing thermocouple check. In this case, the chromel lead is positive, and non-magnetic, and the alumel lead is negative and magnetic.

Similarly, the potentiometer or instrument check follows the same pattern as that prescribed for the rear bearing thermocouple, except that the initial calibration point should be 400 deg. C., thereafter progressing by incremental stages of 100 deg. C. throughout the range of the instrument. The permissible error tolerance for this check is $\pm \frac{1}{2}\%$ at each reading.

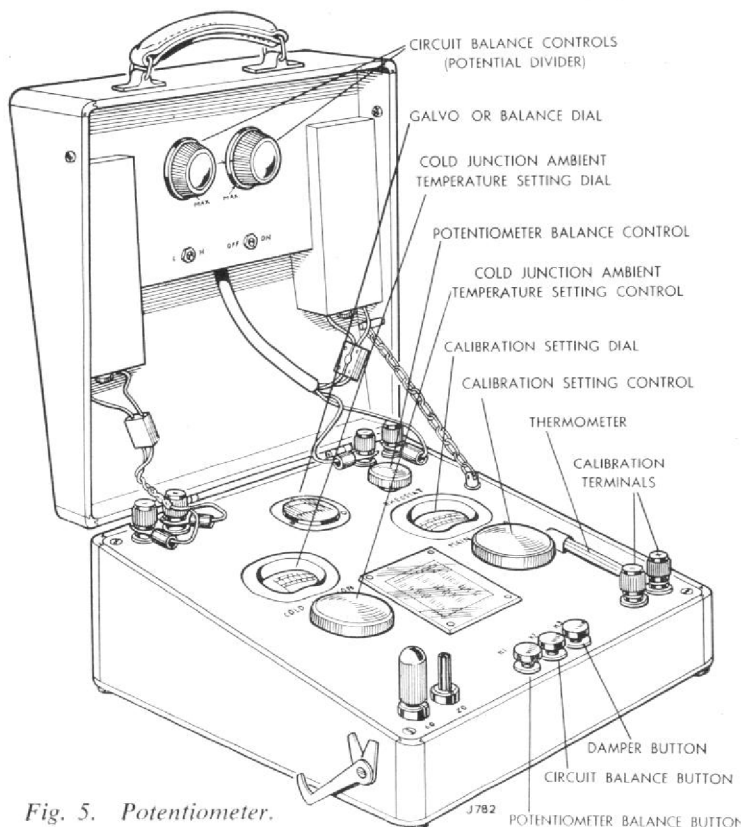


Fig. 5. Potentiometer.

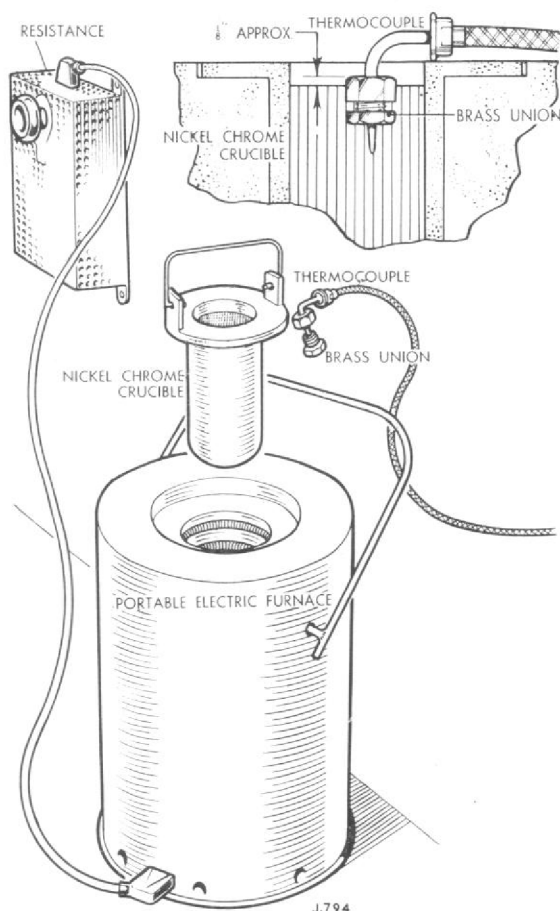


Fig. 6. "Freeze check" equipment.

For the "freeze check" it will be necessary to have the following equipment:—

A Wild Barfield or similar type of nickel chrome crucible approximately $2\frac{1}{2}$ inches in diameter and 3 inches deep, contained within a small portable electric furnace (Fig. 6). A quantity of analar zinc, that is, zinc which is 99.9% pure. The purity of the metal is of the utmost importance, as any latent impurity will affect its thermal characteristics. It is for this reason that zinc is recommended, as it possesses a low oxidation rate.

Place the crucible filled with zinc within the heating element, and as the temperature increases the zinc will ultimately liquify. Continue to heat the crucible until the temperature of the molten zinc reaches about 435 deg. C., the temperature being controlled by means of a resistance connected in the circuit.

Before the thermocouple is placed in the crucible it is recommended that the following precaution is taken to protect the threads of the thermocouple securing nut from zinc adhesion. Obtain a standard $\frac{1}{8}$ in. B.S.F. brass union and screw it into the thermocouple nut. The thermocouple with union attached is then suitably suspended in the molten zinc as shown in Fig. 6 and

the heating element switched off. The extent to which the thermocouple is immersed is most important, as insufficient or over immersion will result in false readings being obtained. When the thermocouple is correctly immersed, the zinc will be within an eighth of an inch of the top of the thermocouple nut. The first observation should then be taken by recording the temperature registered by the thermocouple temperature indicator. Thereafter observations should be taken every half minute during the cooling period of the zinc, which should solidify or "freeze" at 419.5 deg. C. Continue to take readings every half minute until the temperature has dropped well below the "freeze" point, i.e., somewhere between 415 deg. C. and 410 deg. C.

Having completed the calibration, re-heat the crucible until the zinc once more liquifies, when the thermocouple can be removed. Shake and wipe off any zinc that may be adhering to it and remove the union body while still hot.

The remaining three thermocouples should be calibrated in the same manner, care being taken to ensure that each set of observations is accorded to the respective thermocouple. To eliminate possible confusion the four thermocouples should be labelled T, B, L, and R (top, bottom, left, and right) in accordance with their respective positions when fitted to the engine, and viewed from the rear, looking forward. The observation sheet should be constructed in the manner shown in Fig. 7.

With the observation sheet completed, four cooling curves must be formulated by plotting temperature against time as illustrated in Fig. 8. These curves should all follow, very closely, the same pattern, and provided that care has been exercised to accurately record the observations, any deviation of the observed "freeze point" from 419.5 deg. C. during this check will represent a thermocouple, or (where check 2 has disclosed a recording instrument error), a combined thermocouple and recording instrument error. The permissible error tolerance for each thermocouple is $\pm \frac{1}{2}\%$ deviation from standard.

JET-PIPE THERMOCOUPLE CALIBRATION SHEET			
DATE _____			
HALF-MINUTE OBSERVATIONS IN DEGREES CENTIGRADE			
TOP	BOTTOM	LEFT	RIGHT

Fig. 7. Example of jet-pipe thermocouple calibration sheet.

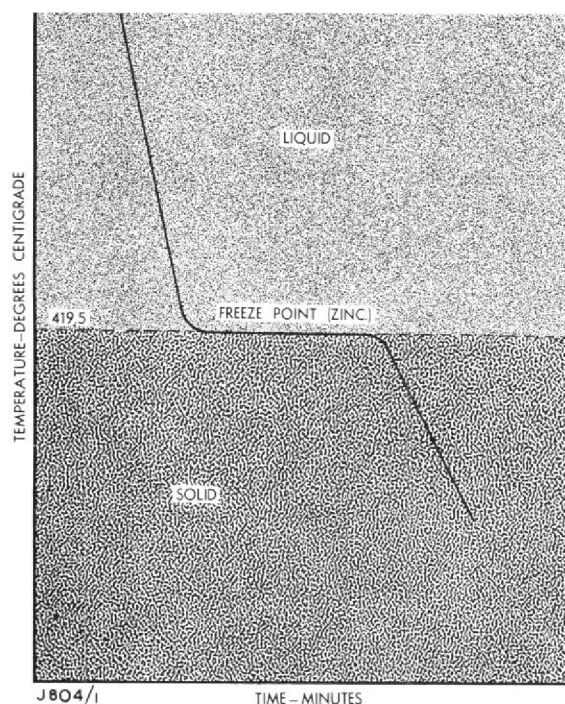


Fig. 8. Analar zinc cooling curve.

ROTAMETER

The Rotameter will be initially calibrated by the manufacturers for a particular fuel of known specific gravity, flowed at a temperature of 65 deg. F. In the case of aviation kerosene the average specific gravity is 0.81 and the Rotameter used during engine testing must be one that has been initially calibrated to this figure. It will be obvious, therefore, that any change in the fuel used, resulting in a change of specific gravity, must necessitate a change of Rotameter to correspond. As changes in the temperature of the fuel will affect the flow characteristics, and consequently the Rotameter readings, it is strongly recommended that during the following calibration check the temperature of the fuel should be maintained as near 65 deg. F. (18.3 deg. C.) as circumstances will permit.

The fuel flow indicator (Rotameter) is normally situated on the instrument panel.

The equipment necessary for the calibration of the Rotameter, as illustrated in Fig. 9, is simple and standard in design.

A platform type weighing machine 0 to 220 lb. is mounted on a low trolley to enable it to be transported to the vicinity of the Rotameter and thus obviate the necessity for removing the instrument. On the platform of the weighing machine is placed a 25 gallon capacity tank, totally enclosed except for a small aperture in the top with a removable cover.

To the side rail of the trolley is attached a two way cock, which in one position permits fuel to flow into the main 25 gallon tank and in the

other position diverts the flow through a drain pipe to a suitable, clean receptacle, e.g., a 40 gallon drum. The third pipe connected to the two way cock is the fuel supply pipe, through which fuel is delivered at a rate determined by a regulating cock connected in the supply pipe.

It will be seen therefore after reference to the piping diagram (Fig. 10) that with the regulating cock open, and dependent upon the positioning of the two way cock, the fuel can flow either from the main fuel supply, through the regulating cock and via the two way cock to the 25 gallon tank, or, from the main fuel supply, through the regulating cock and via the two way cock to the fuel drain.

The principle of calibration is on a time/weight basis and is carried out in the following manner. Disconnect the plant fuel delivery pipe from the engine and connect it to the supply pipe of the calibrating equipment. Ensure that both the 25 gallon tank and the drain tank have been emptied, and that a stop watch is conveniently to hand. Turn the two way cock so that delivery of fuel will be to the drain tank, and by means of the regulating cock adjust the fuel flow to 1000 lb. per hour by the Rotameter scale. Allow a few seconds for the Rotameter to stabilise and then by manipulation of the two way cock transfer the fuel delivery to the 25 gallon tank. Fuel will now be flowing into the tank at the rate of 1000 lb. per hour as indicated by the Rotameter and as the tank commences to fill, the pointer on the dial of the weighing machine will proceed to register the increasing weight.

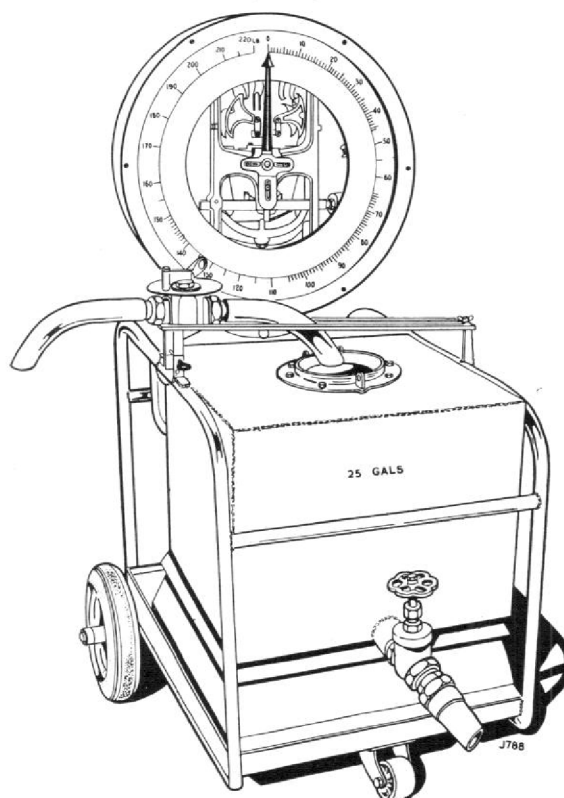


Fig. 9. Rotameter calibrating equipment.

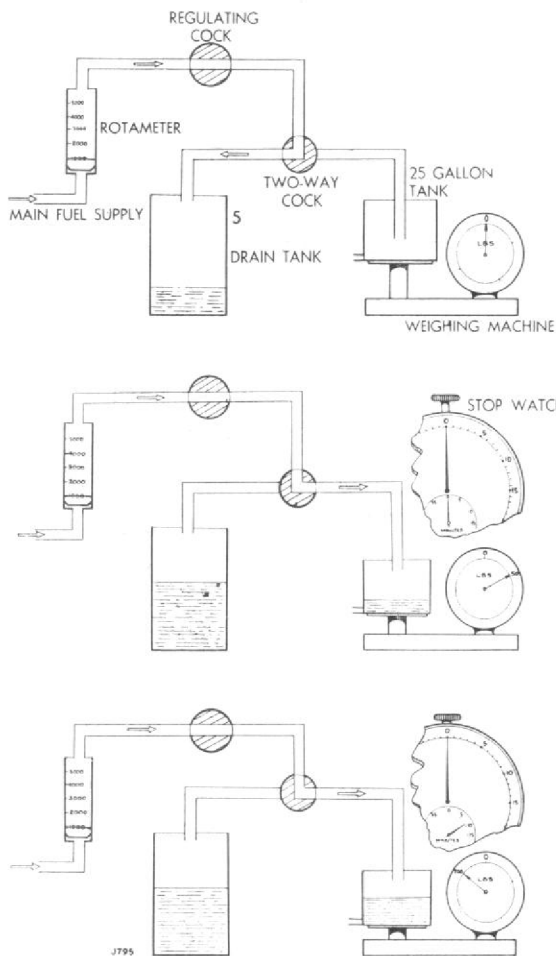


Fig. 10. Diagram showing method of calibrating Rotameter.

With the stop watch pointer at zero and the watch held ready for use, carefully observe the weighing machine pointer as it slowly traverses the weight dial. Select a convenient weight, say 50 lb. and as the pointer passes this reading, start the stop watch. Permit the flow to continue, and as the pointer passes a second convenient reading on the dial, say 200 lb., stop the watch. Turn off the supply cock, and record the time registered by the stop watch.

We know that during the checking period the weight of fuel delivered to the tank was 150 lb. Assuming that on reference to the stop watch the time recorded was 9 minutes, then $\frac{150 \times 60}{9} =$

1000 lb. per hour, representing the calibrated flow. As this result tallies with the initial setting on the Rotameter then at this point at least the Rotameter is accurate.

The calibration is repeated with the Rotameter set to record a flow of 2000 lb. and thereafter, at points increased by incremental stages of 1000 lb. up to the maximum recorded flow on the Rotameter.

It is advisable, particularly at the higher rates of flow, to calibrate with as high a poundage of fuel as possible, thereby minimising the calibration error; the totally impractical ideal, of course, being to measure the flow poundage over the period of one hour.

It is also advisable to drain the 25 gallon tank after each check throughout the calibration.

The permissible tolerance of inaccuracy for the Rotameter is $\pm \frac{1}{2}\%$.

PRESSURE GAUGES

All pressure indicating instruments, other than the glass manometer type, are calibrated with a Budenberg or similar type gauge tester, which is compact and easily accommodated on the average work bench (Fig. 11).

The main body consists of a horizontal brass cylinder filled with hydraulic oil to which variable pressure may be applied by means of a screw-operated plunger having a leather bucket washer at its extremity.

There are two tappings from the oil reservoir; one is at the rear of the apparatus and terminates at the base of a vertical bore of lapped accuracy. Operating within this bore is a ground steel plunger, the plunger within the bore forming a perfect oil-tight sliding fit, the upper end of the plunger being subjected to varying loads by the application of weights. The second tapping from the reservoir is piped away to a standard fixture, to which is attached the instrument to be calibrated. To establish a balance of pressure between them, the diameters of the two tappings are identical. It will be appreciated therefore that with a predetermined pressure applied upon the reservoir oil, by means of the screw plunger, any given load applied to the weight plunger should be accurately registered by the pressure gauge installed on the standard fixture. Two complete sets of weights are supplied with the rig, and the size of weights necessary to supply a complete range of calibrating poundage from 5 lb. to 6000 lb. by 5 lb. stages, depends of course upon the effective pressure area of the weight plunger. To obtain a pound for pound reading, it would be necessary for the weight plunger to have an effective pressure area of 1 sq. in. As it is impractical to operate with weights of actual poundage up to 6000 lb. with this particular test rig, one weight plunger is made with a pressure area of 0.125 sq. in., with the object of applying loads of from 5 lb. per sq. in. to 2000 lb. per sq. in., and a second plunger with a pressure area of 0.02 sq. in. for loads between 300 lb. per sq. in. and 6000 lb. per sq. in. Consequently the sizes of weights necessary to register the actual poundage are thereby considerably reduced in size. The weight of the first plunger plus the weight of the weight platform is such that with all weights removed an initial load of 5 lb. per sq. in. should be registered on the gauge.

The weight of the second plunger plus the loading assembly without weights is such that an initial loading of 300 lb. per sq. in. is applied

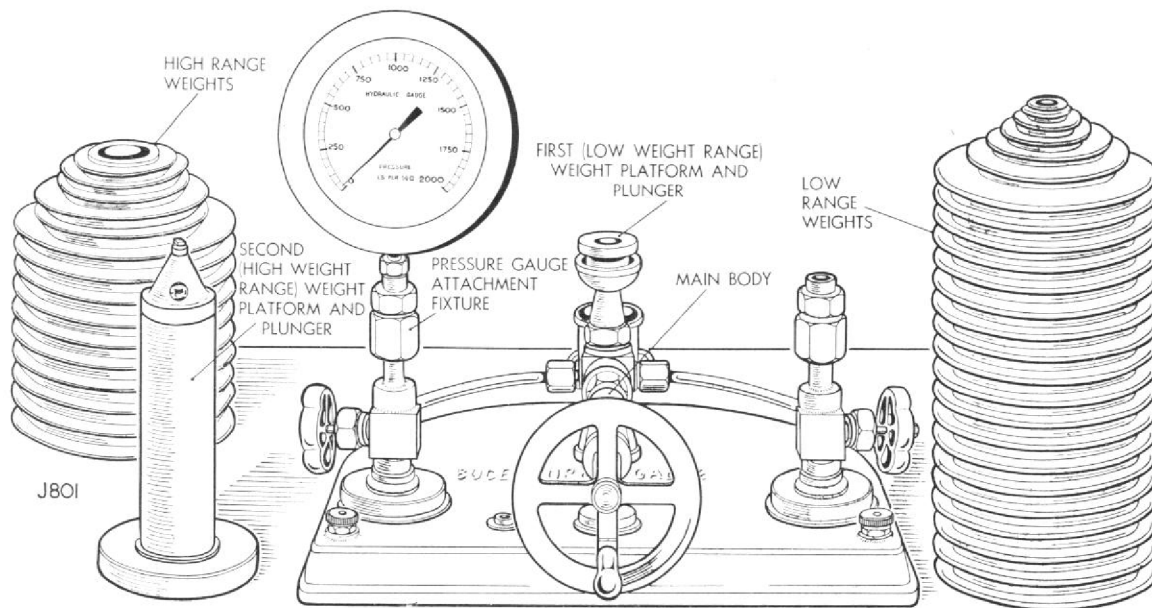


Fig. 11. Budenberg pressure gauge tester.

For calibrating gauges therefore with a range of from 0 lb. per sq. in. to 2000 lb. per sq. in., the first plunger with its associated loading attachment should be used, commencing with the initial loading (all weights removed) of 5 lb. per sq. in., and increasing the load by 100 lb. stages up to the maximum working pressure of the instrument. For gauges with a range of from 0 lb. per sq. in. to 6000 lb. per sq. in., the second plunger and loading attachment should be used, commencing with the initial loading of 300 lb. per sq. in. and increasing the load by 250 lb. stages until the maximum working pressure of the instrument has been reached.

The method of calibration is comparatively simple. The pressure gauge it is intended to calibrate is first installed on the rig at the appropriate fixture, in its normal operating attitude, i.e., horizontal or vertical. Install the relative plunger and loading attachment, remove all weights from the weight platform and by means of the screw-operated plunger apply pressure to the reservoir oil until the loading assembly (weight plunger and weight platform) is riding on the oil and free to rotate. Give the assembly a spin, to eliminate any tendency for the plunger to stick, and record the pressure indicated on the gauge. If the instrument is accurate at this point it should register the initial load, either 5 lb. per sq. in. or 300 lb. per sq. in. according to the plunger in use.

The first weight should then be placed on the weight platform, the pressure on the reservoir oil increased as necessary to ensure the freedom of the loading assembly to rotate, and the pressure recorded. The recorded pressure at this point should, of course, be the initial load plus the value of the weight applied. Increase the loading in stages, recording any instrument error at each stage until the maximum working pressure to

which the instrument is likely to be subjected, when it is in normal use, has been applied. Discretion must be exercised over the question of load application, as the calibrated range of pressure gauges varies considerably. For a gauge calibrated 0 lb. to 100 lb., 10 lb. incremental stages are quite adequate, whereas for a gauge which is calibrated 0 lb. to 5000 lb., the inadequacy is self-evident.

MANOMETER PRESSURE GAUGES

Little calibration is possible with this type of pressure gauge, their simplicity is such that inaccuracy is virtually impossible, provided that they are maintained in serviceable condition and subjected to periodical checks for leaks.

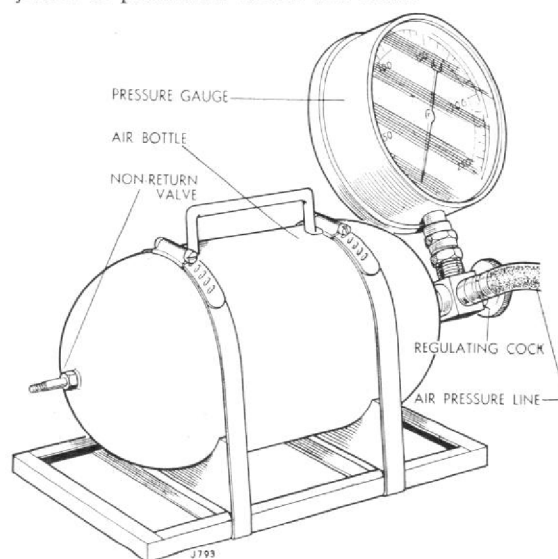


Fig. 12. Gauge line pressurising equipment.

During the servicing, ensure that the glass "U" tube is clean and located securely in a vertical position. Check the level of the liquid, which will be either mercury or coloured water, and see that with both ends of the "U" tube open to atmosphere the level of the liquid in each of the two legs of the tube is the same. Ensure also that this level coincides with the zero marking on the adjustable scale, and that there are no acute downward bends in the pipe line, as these may form moisture traps.

To carry out the leak check, a small air bottle will be required complete with screw cock, non-return valve and pressure gauge as shown in Fig. 12. The bottle is pressurised by means of a hand or foot pump connected to the non-return valve body, to a nominal pressure of about 120 lb. per sq. in. After ensuring that all connections in the manometer pipeline are sound, undo the pressure connection at the engine end and attach it to the pressure connection on the air bottle.

Very carefully open the regulating cock slightly so as to apply a low fixed pressure to the system. 1 lb. of air pressure applied will give a reading of approximately 2.04 in. on a mercury manometer, but 1 lb. of air pressure applied will give a reading of approximately 27.75 in. on a water manometer. Great care must therefore be taken when pressurising the manometer line, as careless application of air pressure will result in the liquid being blown out of the "U" tube.

Having satisfactorily pressurised the line, shut the regulating cock. The air contained within the manometer line should remain at constant pressure during a reasonable period of observation, say three minutes. Failure to do so will denote the presence of a leak or leaks, which should be traced and eliminated.

This procedure is also adopted for checking all pressure lines for leaks after the gauges have been installed in the instrument panel and the lines

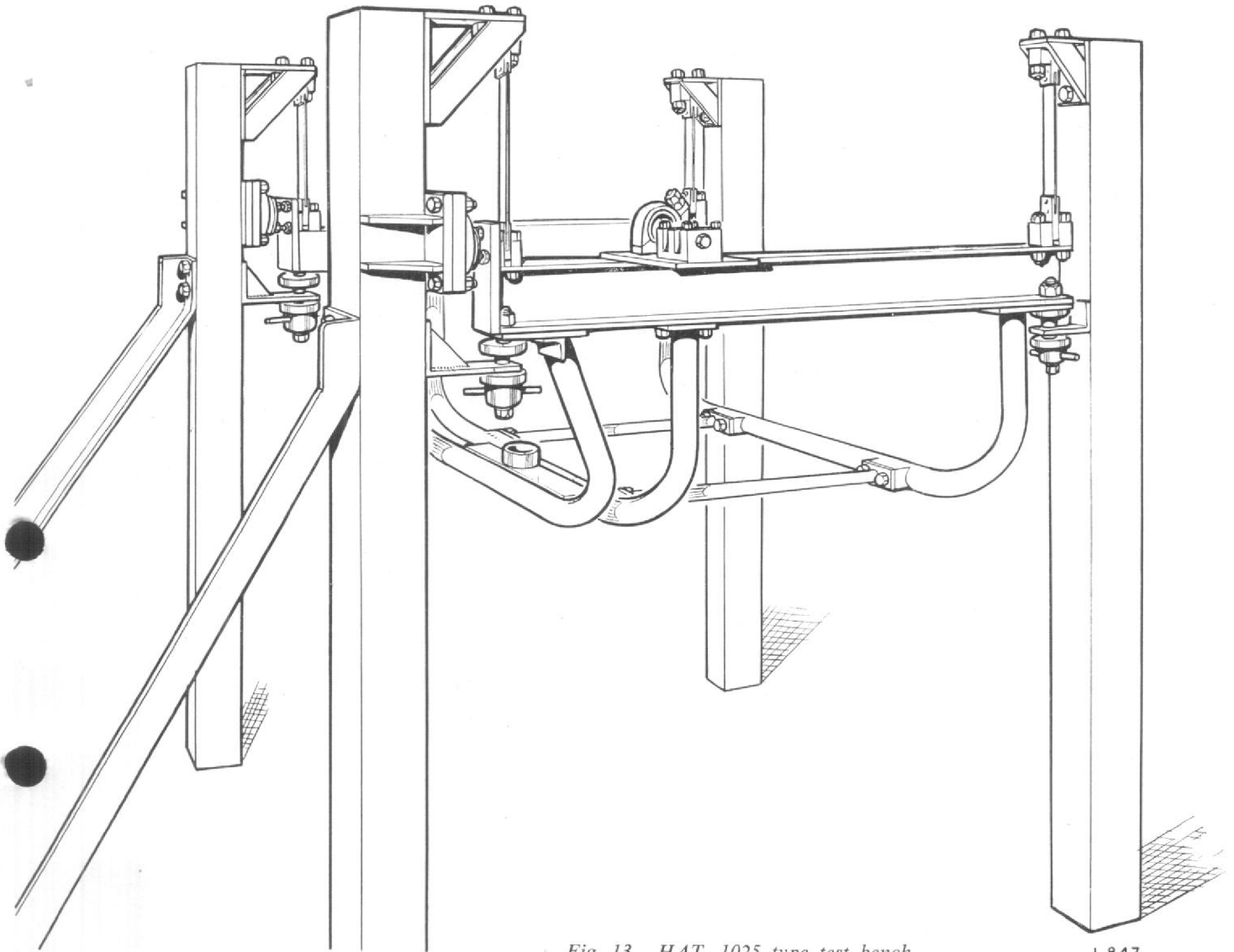


Fig. 13. HAT. 1025 type test bench.

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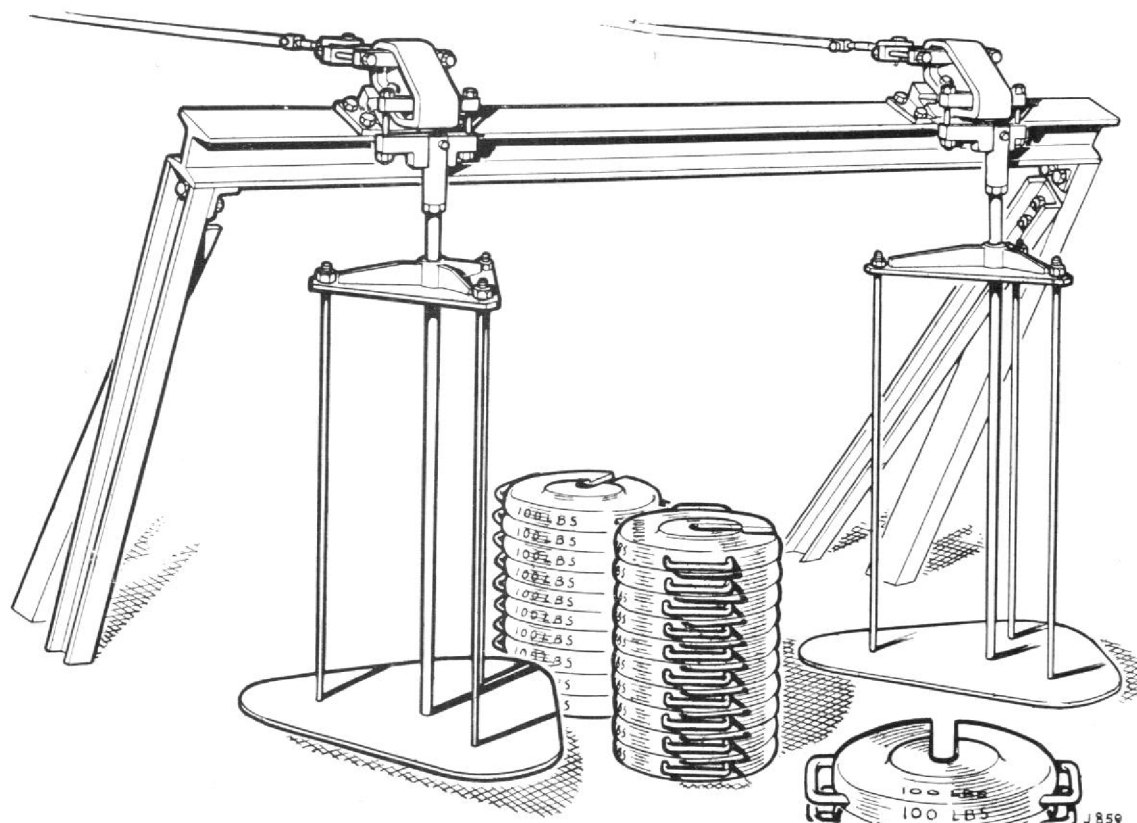


Fig. 14. Test bench loading gear assembled for use.

made up. The gauge lines are pressurised to a sufficient degree to obtain a satisfactory reading on the air bottle pressure gauge, and after shutting the regulating cock to observe the constancy of the reading over a predetermined period.

ERROR CHARTS

In cases where during calibration the instrument error exceeds by a small margin the specified error tolerance, and a replacement instrument is not immediately available it is permissible to construct from the calibration results an error chart. Its construction is simply a representation in graph form of the errors obtained at various instrument readings throughout the calibration; errors being plotted against instrument readings.

The chart is then kept beside the instrument concerned and all readings obtained from the instrument during engine testing should be corrected to the chart before being recorded.

This is only intended as an emergency measure, and a replacement instrument should be fitted at the earliest opportunity.

ENGINE SPEED INDICATOR (TACHOMETER)

The accuracy of the engine speed indicator can best be proved during engine running by comparison with the test bench stroboscope. It is generally accepted that readings obtained from the

E.S.I. can only be regarded as approximations. The stroboscope on the other hand is a far more accurate instrument and consequently it is recommended that wherever possible the E.S.I. should be used to obtain an approximation of the desired speed, reference being made to the stroboscope for final accurate setting. Where it is required to check the accuracy of the tachometer generator or indicator independently, reference should be made to the instructions issued by the appropriate instrument manufacturers.

Where a serious error is noticeable in the registered speed, it is advisable to replace the instrument and return the faulty tachometer generator or indicator to the makers for rectification.

CALIBRATION OF TEST BENCH

THE TEST BENCH recommended for use with these engines is the suspension type HAT.1025 (Fig. 13) and it is with this pattern and the associated equipment that this chapter is concerned.

The test bench itself must be periodically calibrated by a system of dead weight checks, carried out to determine the accuracy with which the engine thrust will be registered when the engine is running. Certain discrepancies inevitably occur between the thrust load applied and the thrust registered on the thrustmeters due to test bench friction and various other mechanical factors, and allowance for this must accordingly be made. The

calibration of a test bench should be carried out at least once a month.

Broadly speaking, the test bench and calibrating equipment is divided into three parts: The main supporting framework and suspension straps; the cradle in which the engine is mounted—which includes the pressure plate for load transference; and the loading gear.

The main framework, rigidly constructed from L section steel, welded together to form square section members, consists of four upright cradle supports. To the top of each of these four members is secured the attachment to which is anchored the upper end of the suspension strap. The straps themselves are made from spring steel strip, which by virtue of their shape and location permit the engine cradle to swing forwards and backwards only. On each of the two front supports is attached a thrust transmitter or pressure pad.

The engine cradle is a simple rectangular framework, with three transverse tubular supports, in which the engine is mounted and secured by two trunnion blocks, one on each longitudinal member. A third pick-up point is situated in the middle of the front tubular cross member. Two anchor blocks bolted to each longitudinal cradle member form the attachments for the lower ends

of the suspension straps, and at the front of each longitudinal member is secured a pressure plate for transferring load or thrust to the thrust transmitters.

Thus it will be seen that the cradle with the engine duly installed is permitted a limited fore and aft movement within the main framework. The extent of the forward movement is decided by the compressibility of the two pressure pads previously referred to. Thus any forward movement of the cradle will result in the pads being subjected to a load which, through the capillaries of the instruments, is registered on the twin thrustmeters.

The third, or loading, section comprises a trestle type girder framework carrying a transverse support beam on which are mounted two knife-edge bearing blocks. Two bell-crank levers with knife-edge bearings are mounted on the blocks with the object of transferring the load from the two weight pans—suspended on knife-edge bearings from the lower end of the bell-crank—through 90 degrees to horizontal drag link-rods. The link-rods are connected at one end to the upper end of the bell-cranks through the medium of knife-edge bearings, and at the other end secured to fixtures mounted on the longitudinal members of the engine cradle.

Any load applied, therefore, to the weight pans will be transferred through the bell-cranks to the horizontal drag link-rods and engine cradle, thence via the pressure plates to the hydraulic pressure pads. These are accordingly compressed and register the load on the calibrated thrustmeters.

METHOD OF CALIBRATION

It is recommended that the weight pans are each adjusted to a standard weight by first weighing them and then, either by removal of small sections of the top plate, in the case of overweight, or, by the addition of a small permanent weight on the top plate, in the case of underweight, bring each pan to a total of 150 lb.

The first step is, of course, to install an engine, as the test bench is always calibrated with an engine in situ with all accessories fitted. The engine installed for the purpose of this calibration need not necessarily be the one it is intended to test. Any engine of the same type will serve, provided that complete installation is effected and that at the completion of the calibration, the setting of the test bench is not disturbed, either during or subsequent to the removal of the engine used.

The engine is prepared and installed in the manner described in chapter 13. The loading gear should then be assembled and positioned as illustrated in Fig. 14 with the weight pans suspended, but without weights. It is then possible to pre-set and level the apparatus, and it cannot be too strongly emphasised that the levelling operation is of the utmost importance and that accurate and consistent readings during test bench calibration can only be obtained when the levelling instructions

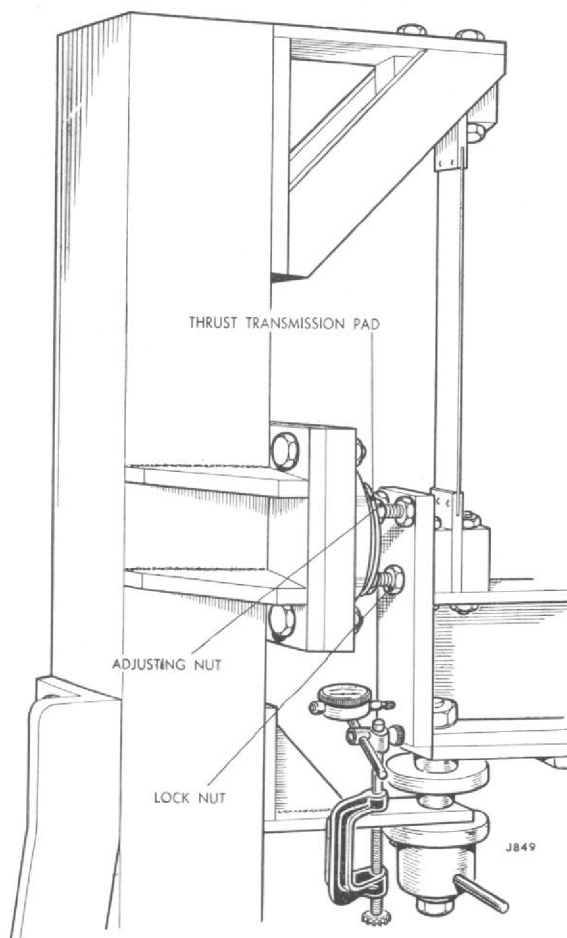


Fig. 15. Thrust pad assembly pre-set.

Fig. 16. Diagram showing essential points to be considered when lining-up and levelling the test bench loading gear.

are rigidly adhered to. In addition, for the equipment to function satisfactorily the following details must be observed.

With the engine installed and suspended freely in the cradle, adjust the setting bolts situated in the pressure plates (see Fig. 15), so that they are just in contact with their respective pressure pads, but not applying a load thereon. Suitably mount a dial indicator at some convenient point, adjacent to each pressure plate, and with each indicator in contact with the rear face of the pressure plate, set the indicator dials to zero. Adjust the setting bolts equally in an anti-clockwise direction until each dial indicator reads 0.015 in., and lock the bolts by means of the locknuts. The test bench is now pre-set and will accordingly register a small addition to the original thrustmeter readings. The total loading will now represent the weight of the two weight pans and bell-cranks, inclusive of any equipment error, plus a small addition due to the pre-setting. This latter addition and the equipment error will ultimately be accounted for when applying thrust readings to the thrustmeter correction chart.

The two thrustmeter readings must, of course, be added together to give the total loading, or, with the engine running, thrust reading. Remove the dial gauges.

An imaginary horizontal line should run through the centre of the engine bearer mounting in the trunnion block, the centre of the thrust transmitter, and right down the centre of the drag link-rod to the upper knife-edge bearing in the bell-crank. It is imperative also to avoid creating a fluid head within the thrust recording apparatus that the height of the thrustmeters, measured from the centre of the dials to the ground, is the same as the imaginary datum line referred to. Having ascertained that the equipment positioning conforms to the above requirements, place a spirit

level on the top horizontal edge of each bell-crank and ensure that both are absolutely level. In the event of any levelling adjustment being necessary, correction should be applied by manipulation of the drag link-rod retaining nuts (Fig. 16).

[illegible]

Fig. 17. Example of thrust calibration sheet.

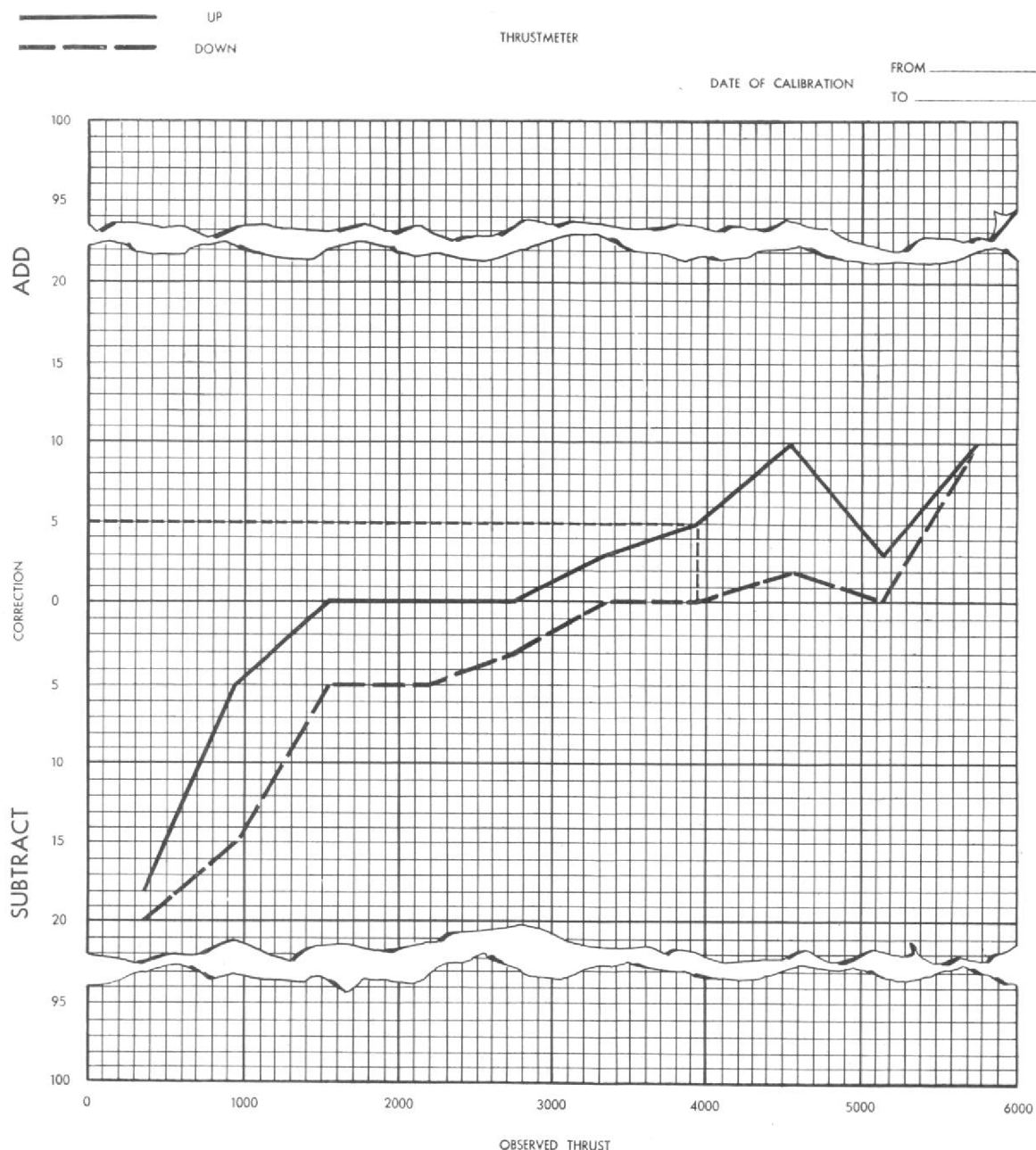


Fig. 18. Example of thrust-meter correction chart.

The test bench is now in readiness for calibration, and in explaining the procedure, it will be more easily understood if a hypothetical example is taken, and the twin thrustmeters referred to as D.H.1 and D.H.2.

The weight of the weight pans has already been adjusted, so that they will constitute a combined load of 300 lb. when we suspend them on the bell-cranks.

Due to the angle at which they are mounted, the bell-cranks, by virtue of their weight, exert a loading effort of 20 lb. each. Thus an additional

weight is initially imposed, and the calibration is commenced with an all up initial loading compiled in the following manner:—

Weight pans (two at 150 lb.)	300 lb.
Bell-cranks (two at 20 lb.)	40 lb.
Total	340 lb.

The thrustmeters however register the following loads: D.H.1=180 lb., D.H.2=178 lb. Total =358 lb.

A calibration sheet constructed in the manner shown in Fig. 17 will provide a clear and concise record, and the first entry thereon will read:—

<i>Actual up</i>			
<i>Load</i>	<i>D.H.1</i>	<i>D.H.2</i>	<i>Error</i>
340	180	178	+18

The first set of 100 lb. weights is then applied, three weights on each weight pan, so that we now have a total actual load of 940 lb. Before recording the thrustmeter readings however, the level of the equipment must be checked by means of the spirit level placed on the top edge of each bell-crank, and any necessary adjustment accordingly made. Once parallelism with the horizontal datum line has been established the thrustmeters can be read, the error noted, and the observations recorded as before. The same procedure is adopted with each 600 lb. addition to the load, paying particular attention to the levelling operation prior to reading the thrustmeter after each loading, until the maximum load has been applied.

A repeat set of observations is then recorded reducing the load by 600 lb. stages, and levelling at each stage before reading the thrustmeters, until all the weights have been removed, and the first set of observations completed.

The calibration is carried out three times and the mean observed thrustmeter reading at each stage entered in the appropriate column on the right hand side of the observation sheet. Similarly, the mean error is inserted in the adjoining "ERROR" column. These average figures are the ones used in the construction of the correction chart.

The loading gear can now be dismantled and the test bench will be ready for engine testing, but before thrust readings obtained during the testing of the engine can be corrected for calibration error, the correction chart must be drawn and the correction curve formulated. The curve

is produced by plotting the mean observed load against the mean recorded error, as illustrated in Fig. 18. It will be noticed that two curves are actually drawn, one applicable to that part of the calibration where the loading is increased (UP); the other applicable to that portion where the loading is decreased (DOWN).

It will be noticed that in the construction of the correction chart the error sign is reversed. The reason for this of course is that with an actual load of 340 lb. (weight pans 300 lb. + bell-cranks 40 lb.), and an observed figure of 358 lb. the thrustmeters are over-reading (+) to the extent of 18 lb. Therefore, when applying an equivalent observed thrust for correction, 18 lb. must be deducted (—). Assuming, therefore, that during testing, the engine is opened up until a thrust of 3950 lb. is recorded on the thrustmeters; to correct this reading for calibration error, it would be necessary to select 3950 lb. on the thrustmeter correction chart thrust scale and extend this point vertically upwards until the "UP" curve line is intersected. Reading the correction scale on the left hand side of the chart, we find that it is necessary to add 5 lb. to the observed thrustmeter reading, i.e. $3950 + 5 = 3955$ lb., which will represent instrument corrected thrust.

If however in the course of testing, the engine has been throttled back to 3950 from some higher thrust reading, then it will be necessary to refer to the "DOWN" curve of the correction chart. In this case therefore, at 3950 lb. we find the error to be NIL, so that no alteration to the original figure will be necessary.

SERVICING TOOL KIT

The servicing tool kit is listed and illustrated on the pages which follow. For a complete list of the tools and equipment required to carry out complete engine overhaul, reference should be made to the separate publication which is issued by the Service Department of The de Havilland Engine Co.

<i>Tool No.</i>	<i>Description</i>	<i>Qty.</i>
TOOLS FOR USE ON FUEL SYSTEM		
T.73692	Spanner for fuel filter	Fig. 19 { 1
T.73693	Bar tommy, for fuel filter socket	
T.75050	Gauge—pressure	Fuel system checks { 1
T.75051	Gauge—pressure	
T.72181	Spanner—jaw governor adjusting screw	 1
T.75864	Tool—adjusting, slow-running bleed control valve assembly	 1
TOOLS FOR USE ON BURNERS		
T.72788	Distance gauge—burner protrusion	Fig. 20 { 1
T.72789	Setting fixture for use with T.72788	

<i>Tool No.</i>	<i>Description</i>	<i>Qty.</i>
TOOLS FOR USE ON COMBUSTION CHAMBERS		
T.72178	Spanner, Cee, combustion chamber interconnector coupling.. ..	2
T.72170	Spanner, adjustable claw, combustion chamber couplings	2
T.74279	Spanner, swivel, $\frac{1}{4}$ in. Whit. combustion chamber bolts	1
T.74280	Spanner, swivel, $\frac{3}{16}$ in. Whit. combustion chamber bolts	1
TOOLS FOR USE ON OIL SYSTEM		
T.74176	Tool adjusting oil pressure relief valve, Fig. 21	1
TOOLS FOR USE ON TURBINE		
T.71156	Gun-inhibiting for turbine disc	1
M/W 492	Gauge, feeler, for blade tip clearance	1
—	Lens, magnifying—electric, for blade crack detection	1
TOOLS FOR USE ON TURBO-STARTER		
T.74832	Spanner—turbo-starter nuts, Fig. 22	1
TOOLS FOR GENERAL USE		
D.H. Mk. 3, 2BA	Spanner—semi-universal box 2 B.A. ..	1
D.H. Mk. 3, $\frac{3}{16}$ in.	Spanner—semi-universal box $\frac{3}{16}$ in. Whit... ..	1
D.H. Mk. 3, $\frac{1}{4}$ in.	Spanner—semi-universal box $\frac{1}{4}$ in. Whit. ..	1
D.H. Mk. 3, $\frac{5}{16}$ in.	Spanner—semi-universal box $\frac{5}{16}$ in. Whit... ..	1
O.I.B. 203	Spanner—D/E Jaw 3 B.A. $\times$ 2 B.A.	1
OL.W. 204	Spanner—D/E Jaw $\frac{1}{4}$ in. $\times$ $\frac{5}{16}$ in. Whit.	1
OL.W. 202	Spanner—D/E Jaw $\frac{1}{8}$ in. $\times$ $\frac{3}{16}$ in. Whit.	1
OL.W. 206	Spanner—D/E Jaw $\frac{3}{8}$ in. $\times$ $\frac{7}{16}$ in. Whit.	1
OL.W. 208	Spanner—D/E Jaw $\frac{1}{2}$ in. $\times$ $\frac{9}{16}$ in. Whit.	1
OL.W. 209	Spanner—D/E Jaw $\frac{9}{16}$ in. $\times$ $\frac{5}{8}$ in. Whit.	1
A.2609	Spanner—Jaw/Ring, $\frac{1}{8}$ in. Whit.	1
A.2610	Spanner—Jaw/Ring, $\frac{3}{16}$ in. Whit... ..	1
A.2611	Spanner—Jaw/Ring, $\frac{1}{4}$ in. Whit.	1
A.2612	Spanner—Jaw/Ring, $\frac{5}{16}$ in. Whit... ..	1
A.2613	Spanner—Jaw/Ring, $\frac{3}{8}$ in. Whit.	1
A.2614	Spanner—Jaw/Ring, $\frac{7}{16}$ in. Whit... ..	1
A.2615	Spanner—Jaw/Ring, $\frac{1}{2}$ in. Whit.	1
D.D.W. 212	Spanner— $\frac{3}{4}$ in. $\times$ $\frac{7}{8}$ in. Whit. D/G Ring, sump plug	1
—	Pliers—8 in. side cutting.. ..	1
—	Pliers—8 in. long nose	1
S.D.R. 608	Screwdriver—8 in. blade.. ..	1
S.D.R. 613	Screwdriver—13 in. blade	1
A.T.H. 7	Tachometer—hand	1
T.75482	Tool—lockwire, Fig. 23	1

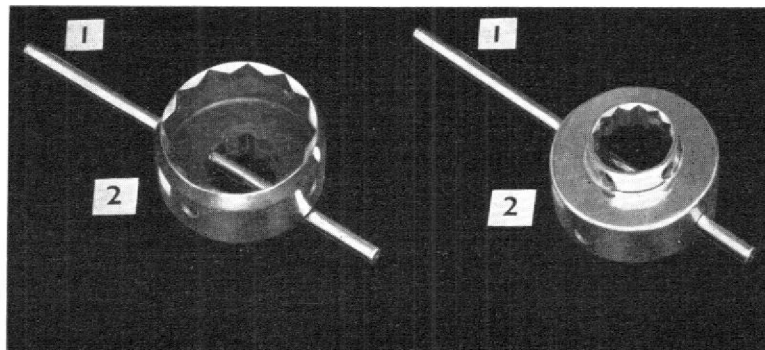


Fig. 19. Two views of socket and tommy bar for fuel filters.

1. T.73693, tommy bar for T.73692.

2. T.73692, socket for fuel filters.

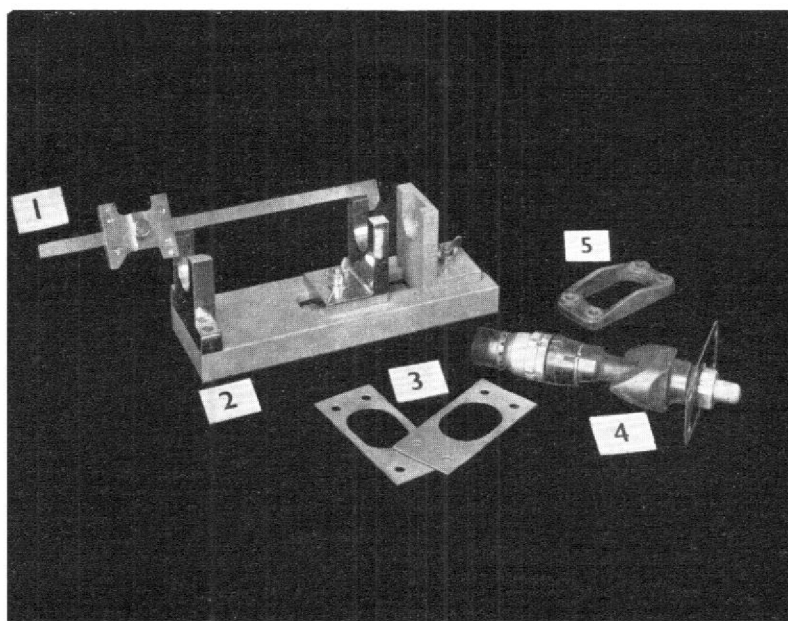


Fig. 20. Burner protrusion setting equipment.

1. T.72788, distance gauge.

3. Adjusting washers, Part No. 26307.

2. T.72789, setting fixture.

4. Burner complete with diaphragm.

5. Burner diaphragm cover.

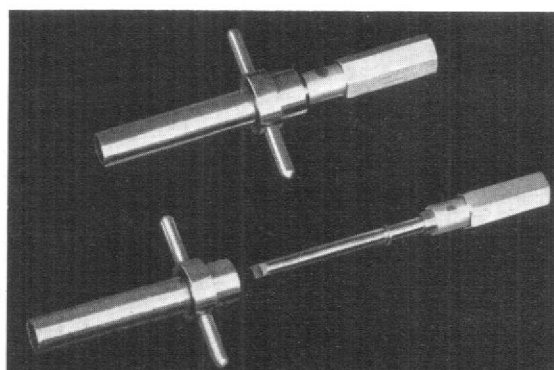


Fig. 21. Tools for adjusting oil pressure relief valve.
Combined spanner and screwdriver T.74176 used to adjust oil pressure relief valve;
shown assembled and dismantled.

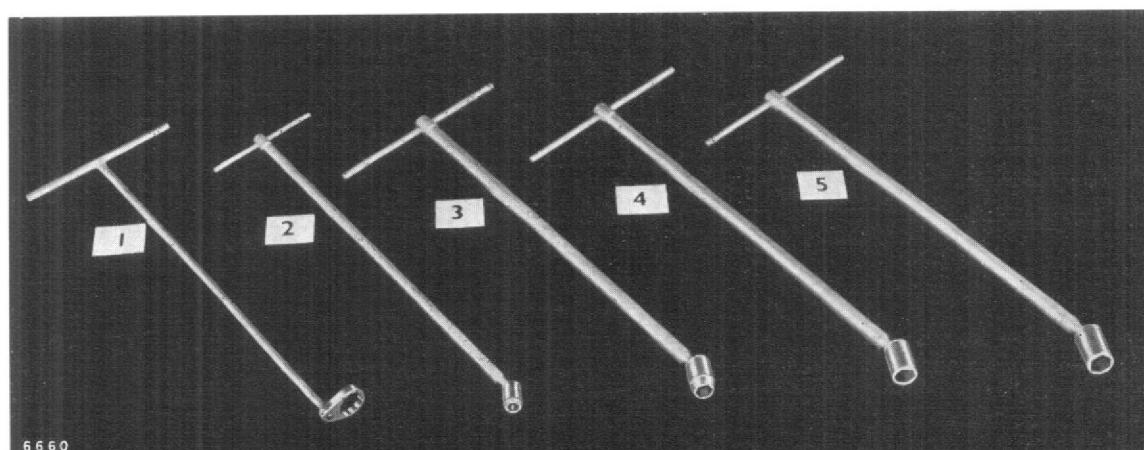


Fig. 22. Turbo-starter and semi-universal box spanners.

1. T.74832, spanner for turbo-starter nuts.
2. D.H. Mk. 3—2 B.A., 2 B.A. Semi-universal box spanner.
3. D.H. Mk. 3— $\frac{3}{16}$ in., $\frac{3}{16}$ in. Whitworth semi-universal box spanner.
4. D.H. Mk. 3— $\frac{1}{4}$ in., $\frac{1}{4}$ in. Whitworth semi-universal box spanner.
5. D.H. Mk. 3— $\frac{5}{16}$ in., $\frac{5}{16}$ in. Whitworth semi-universal box spanner.

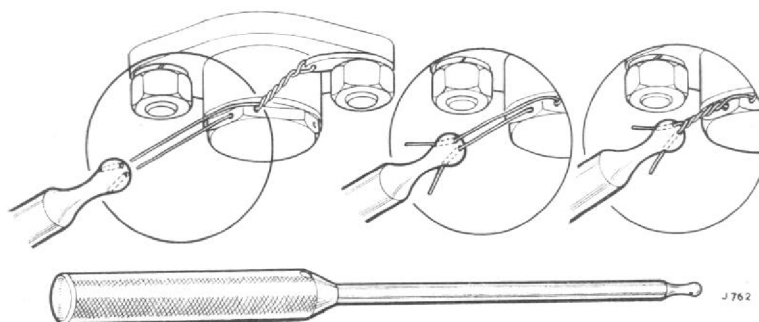


Fig. 23. Lockwire tool.

Introduction

Pages 19 to 27 contain details of those jigs and tools which can conveniently be made locally when the need arises, together with a brief description of the more complex items as an aid to a ready understanding of their use.

Before manufacture is commenced, a check should be made that the item under consideration has not been provisioned as a standard item subsequent to the issue of this chapter.

The tools required for each stage of work on the engine are listed in the chapters dealing with those stages, and the application of these tools forms an integral part of each chapter.

Electro-magnetic coil

Fig. 24 gives the dimensions for the manufacture of an 8 in. diameter coil suitable for the electro-magnetic crack detection of steel engine components. A 4 in. diameter coil for small items should be similar except for the internal diameter and the width of the wooden base, i.e. 8 in. diameter becomes 4 in. diameter, and $7\frac{1}{2}$ in. width of base becomes $3\frac{3}{4}$ in.

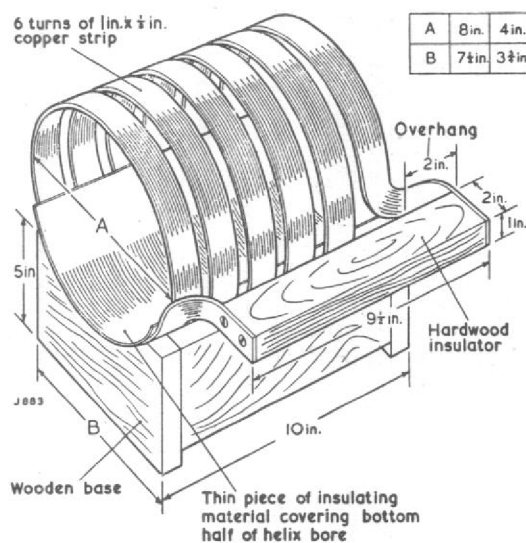


Fig. 24. Coil for electro-magnetic tests

Turbine disc stand

A turbine disc stand for temporary storage or transport on a flat trolley between operations can be made up to the dimensions given in fig. 25. Any suitable wood may be used.

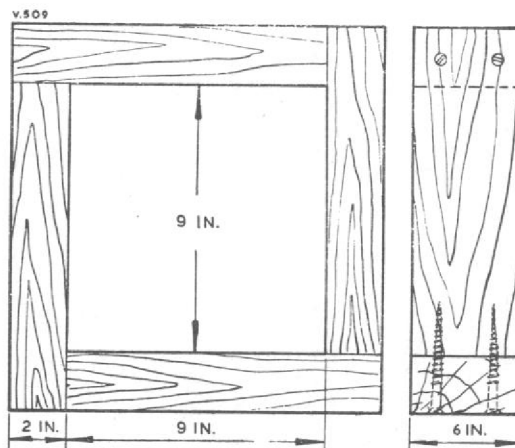


Fig. 25. Stand for turbine disc

Straight edge

A straight edge for checking the edges of nozzle blades can be manufactured to the dimensions given in fig. 26. The use of this tool is illustrated in Chapter 27J.

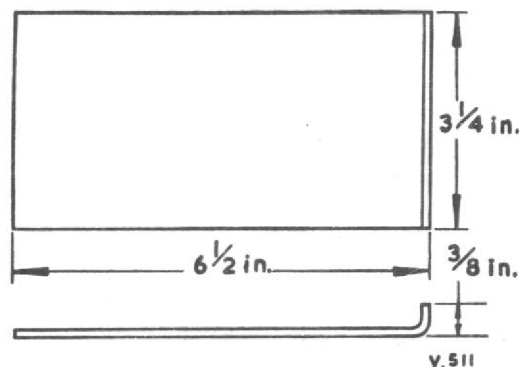


Fig. 26. Straight edge for nozzle blades

Disc gauges

A disc of the correct diameter to suit the particular component is all that is necessary to check the ovality of a propelling nozzle or venturi cuff. The following table gives a list of disc sizes, and Chapter 27L illustrates their use.

Disc gauge dimension

Nominal size of nozzle in.	Type	Dia. of nozzle gauge in.	Dia. of venturi cuff gauge in.
18-500	Fixed	18-495-0-010	20-125-0-010
18-625	Fixed	18-620-0-010	20-243-0-010
18-750	Fixed	18-745-0-010	20-378-0-010
18-625	Adjustable	18-620-0-010	20-245-0-010
18-875	Adjustable	18-870-0-010	20-495-0-010

The range of discs can readily be manufactured locally from $\frac{1}{8}$ in. steel sheet (fig. 27), but great care must be taken to ensure that they are truly circular; it is not sufficient to check the diameter of the disc only.

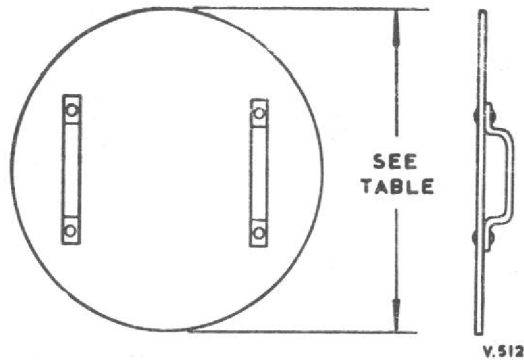


Fig. 27. Disc gauge for venturi cuff and propelling nozzle

Duralumin blocks (48 Mk. 1 and 48 Mk. 2)

Two duralumin blocks manufactured from local resources to the dimensions in fig. 28, will prevent damage by swarf to turbine discs during blade peening operations. One block should be placed between the end of each steady bolt and the disc; the use of the two blocks is illustrated in Chapter 28C.

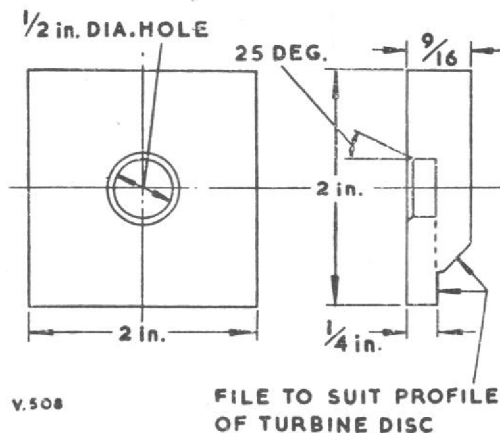


Fig. 28. Duralumin blocks for peening fixture

Lathe adapter (48 Mk. 1 and 48 Mk. 2 pre-mod. 871)

The essential dimensions of a lathe adapter for the turbine blade tip grinding fixture T76595 are given in fig. 29.

Tube spanner

As an alternative to locking plate T74967 and key T74968, used when assembling the air-intake to the motoring-over rig, a tube spanner and locking plate may be manufactured from local resources to the dimensions given in fig. 30. The

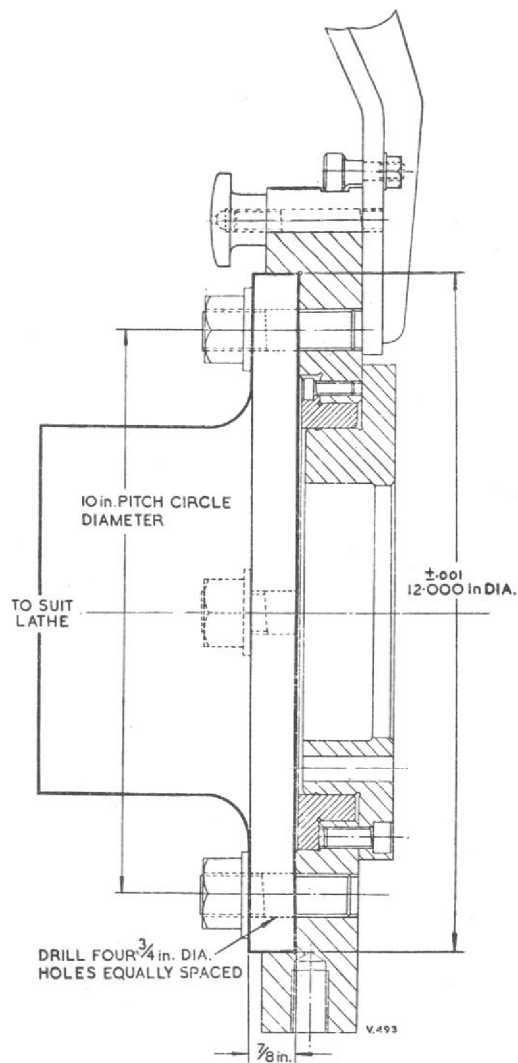


Fig. 29. Lathe adapter for grinding fixture T76595

application of this tool is illustrated in Chapter 33B.

Extractor

Fig. 31 gives the dimensions for the manufacture of an extractor to remove the motoring-over rig drive coupling from the horizontal driving gear.

Lifting adapter

Air-intake lifting sling T70454 does not provide a good C. of G. location. A lifting adapter to the dimensions in fig. 32 can be manufactured from local resources and will facilitate ease of handling.

Blanks

Perspex blanks to cover the 48 Mk. 1 hydraulic and vacuum pump mounting faces can be made up from scrap perspex to the dimensions given in fig. 33. A perspex blank for the 48 Mk. 2.





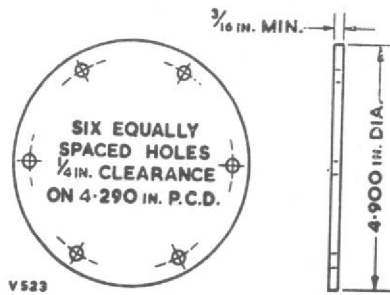


Fig. 33. Blanks for accessory mounting faces (48 Mk. 1)

valve group mounting face can be manufactured to the dimensions given in fig. 34. Chapter 33B, describes the use of these blanks.

Exhaust cone anvil

The inner exhaust cone anvil, used when removing dents from the inner exhaust cone, can be made up in accordance with the dimensions

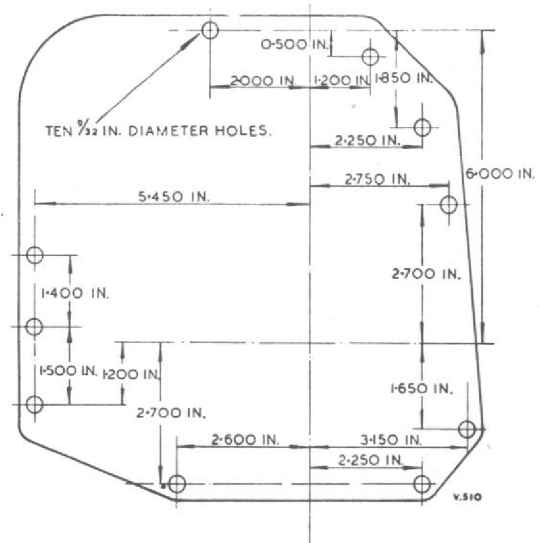


Fig. 34. Blank for valve group mounting face (48 Mk. 2)

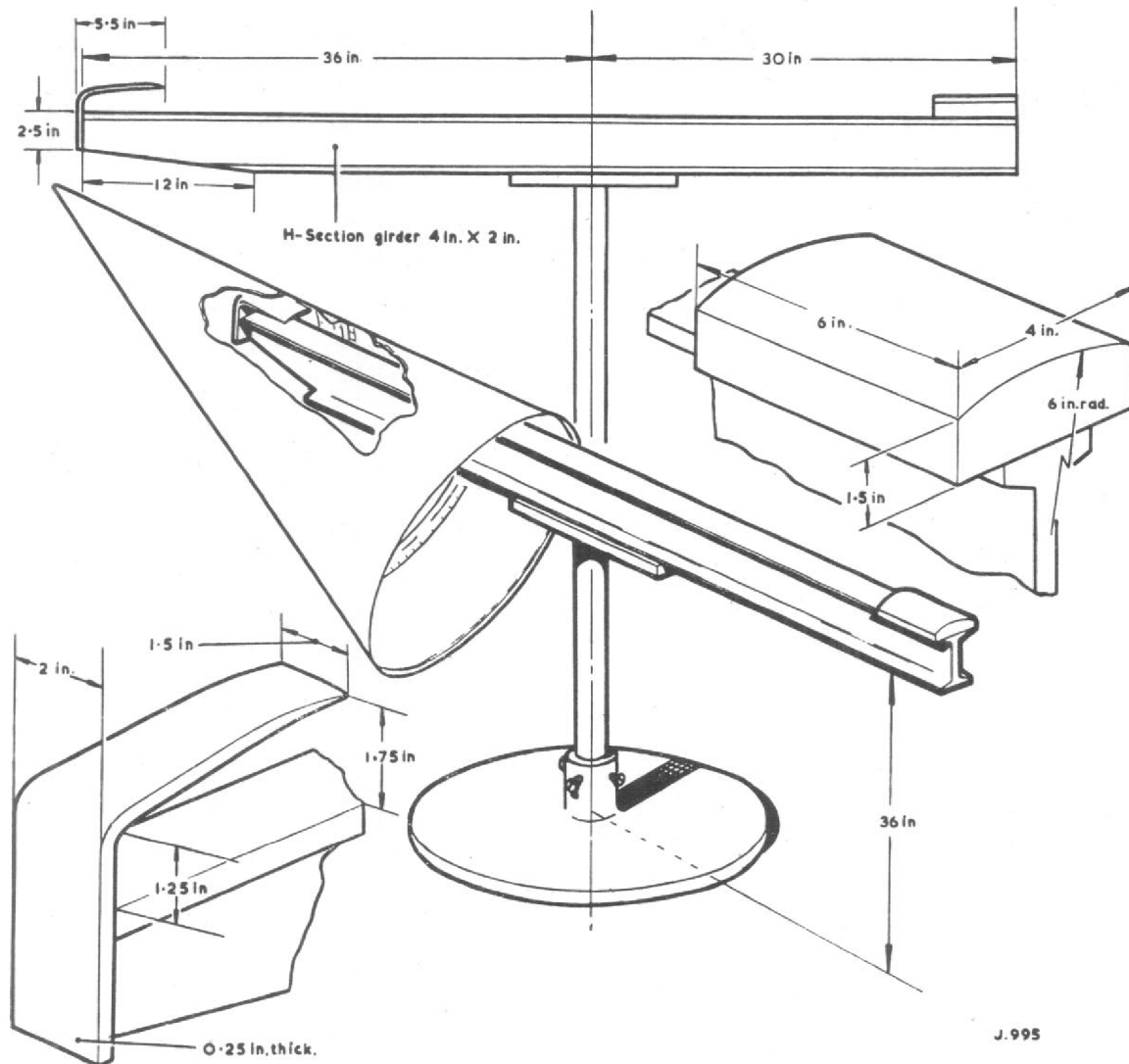


Fig. 35. Anvil for inner exhaust cone

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November, 1956

given in fig. 35. The use of the anvil is described in Chapter 33K.

Protrusion gauge

A support tube protrusion gauge for use during the assembly of the exhaust cone can be made in accordance with the dimensions shown in fig. 36. The use of the gauge is described and illustrated in Chapter 33K.

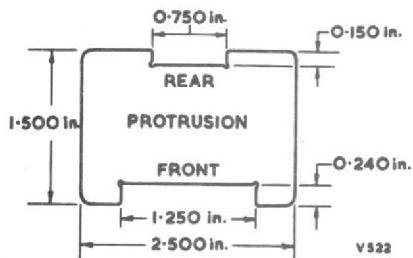


Fig. 36. Protrusion gauge for support tube

Slip gauge

A suitable slip gauge for checking the relationship between the inner exhaust cone and the outer cone flange can be made in accordance with the dimensions in fig. 37. Its use is described and illustrated in Chapter 33K.

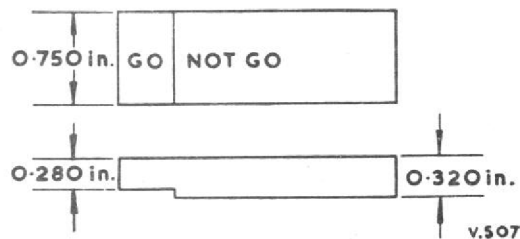


Fig. 37. Slip gauge for exhaust cones

Priming adapter

An adapter for priming the rear bearing can be made in accordance with fig. 38. The use of this adapter is described in Chapter 8.

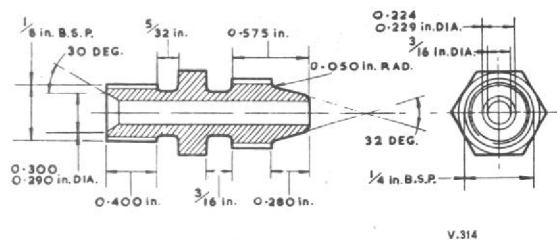
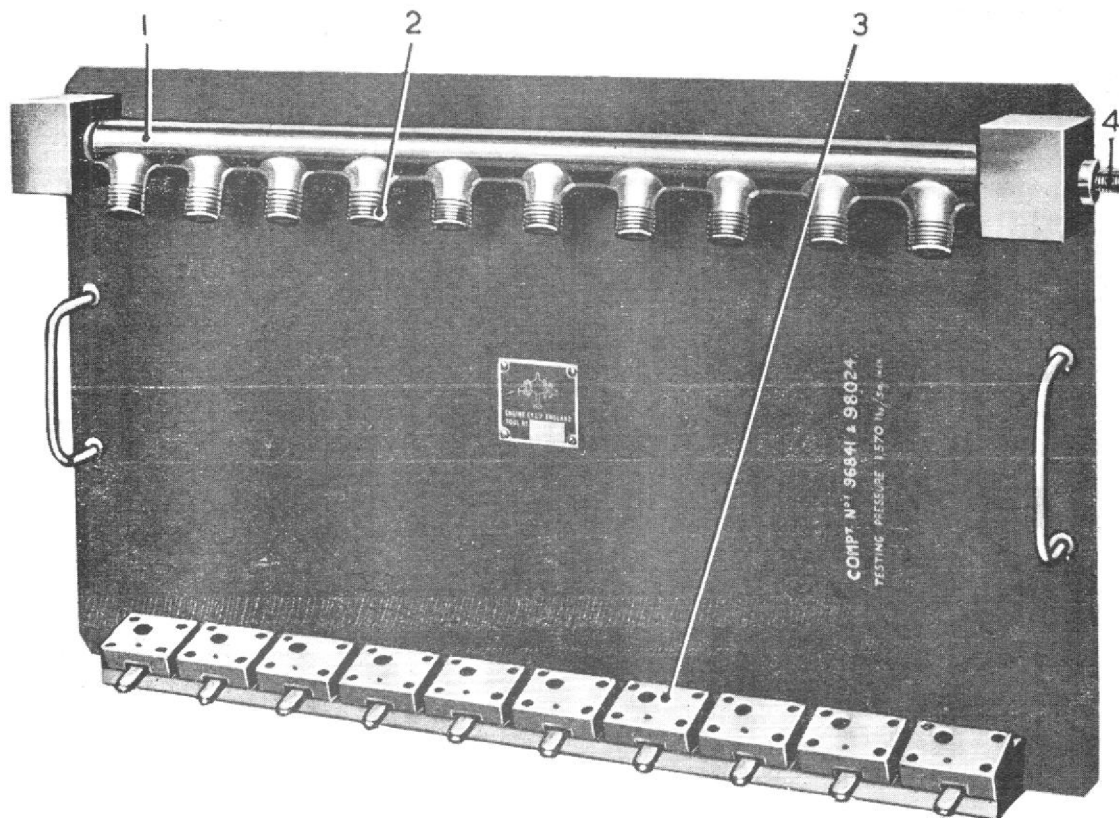
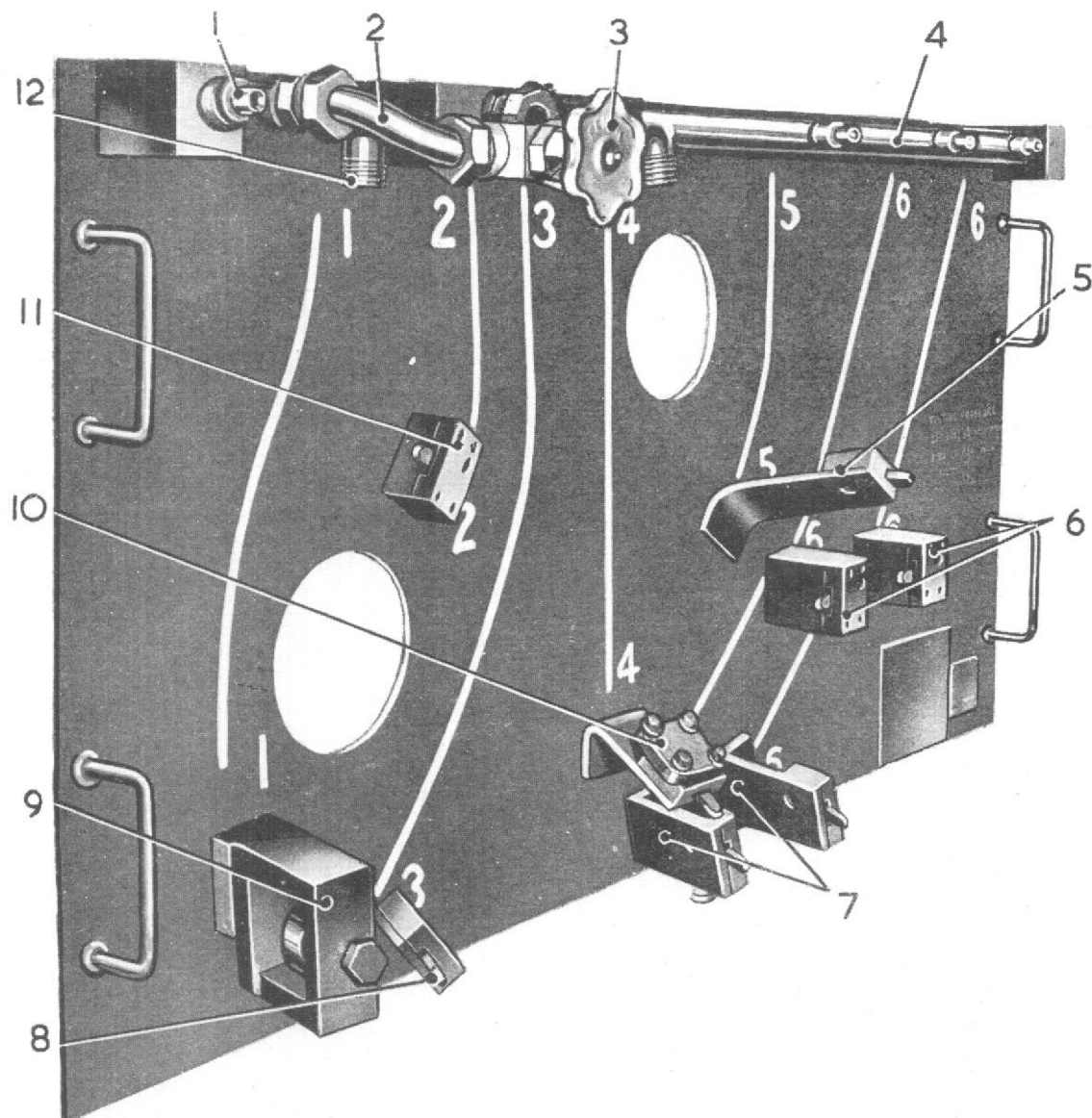


Fig. 38 Priming adapter for (48 Mk. 1) where mod. 1095 has been embodied, and (48 Mk. 2) rear bearing.



- 1 H.P. FLUID GALLERY
- 2 TEN ADAPTERS FOR MANIFOLD FEED PIPES
- 3 TEN QUICK-RELEASE FITTINGS FOR MANIFOLD FEED PIPES
- 4 PRESSURE PUMP ADAPTER

Fig. 39. Pressure test rig T78757 for flexible pipes



- | | | |
|--|--|--|
| 1 PRESSURE PUMP ADAPTER | 6 CENTRE QUICK-RELEASE FITTINGS FOR THE TWO COMBUSTION DRAIN PIPES | 9 QUICK-RELEASE CLAMP FOR THE BANJO END OF THE A-F.R.C. UNIT TO CIRCULATING PUMP AND VALVE GROUP UNIT PIPE |
| 2 BY-PASS FROM THE MAIN FLUID GALLERY TO THE ISOLATED SECTION | 7 END QUICK-RELEASE FITTINGS FOR THE TWO COMBUSTION DRAIN PIPES | 10 QUICK-RELEASE FITTING FOR THE FEED FROM L.P. FILTER TO FUEL PUMP PIPE |
| 3 HIGH PRESSURE SHUT-OFF VALVE | 8 QUICK-RELEASE FITTING FOR THE COOLING FEED FROM FUEL PUMP TO CIRCULATING PUMP PIPE | 11 QUICK-RELEASE FITTING FOR THE METERING PUMP FEED PIPE |
| 4 MAIN FLUID GALLERY | | 12 ADAPTER ON H.P. FLUID GALLERY FOR THE A-F.R.C. UNIT TO CIRCULATING PUMP AND VALVE GROUP UNIT PIPE |
| 5 QUICK-RELEASE FITTING FOR THE RESTRICTOR TO FRONT BEARING PIPE | | |

Fig. 40. Pressure test rig T78755 for flexible pipes

Pressure test rigs

There are eight rigs for pressure testing flexible pipes, each one accommodating a group of pipes which have to be tested to the same pressure. Two of the rigs are illustrated in fig. 39 and 40. Each rig consists of a steel base provided with a high-pressure fluid gallery along one side and blanking plugs for the free ends at the other; the gallery has adapters to accommodate one end of the pipes, and the blanking fittings are situated in various positions on the base to allow each pipe to assume the approximate shape it will occupy when assembled to the engine. Each blanking

fitting has a quick-release device to enable one end of the pipe to be released so that the pipe can be flexed as required by the test specification. White lines painted on the base indicate the run of each pipe, and a plate screwed to the base stipulates the pipe station and part number. A suitable pump must be used to supply fluid to one end of the gallery so that the pipes can be tested to the specified pressure. A valve is incorporated to release the air when priming the gallery and the pipes, also the fluid pressure before disconnecting the pipes. One or more handles are provided at each end to facilitate handling.

The rigs and the pipes tested by them are as follows:—

Pipe test rig details

Rig No.	Pipes	Test pressure lb. per sq. in.
48 Mk. 1		
T78210	Ten burner feed	2,900
T78212	Front pump to rear pump delivery pressure	3,400
	Rear pump to high pressure filter	3,400
	Front pump to B.P.C. delivery pressure	3,400
	B.P.C. to A-F.R.C. servo pressure	3,400
	Pump to pump servo pressure	3,400
	Front pump to B.P.C. servo pressure	3,400
T78216	Two combustion chamber drain	250
	Control valve to B.P.C. to pump spill	250
	Metering pump to No. 10 diffuser bolt, Pre-mod. 1095	250
	Low pressure filter to front pump	250
	A-F.R.C. to control valve, spill	250
	Restrictor to front bearing	250
T78214	Control valve to distributor	3,000
	Control valve to A-F.R.C. metered pressure	3,000
T78218	H.P. pressure filter to control valve	3,380
48 Mk. 2		
T78757	Nine manifold feed	1,570
	One manifold feed connection	1,570
T78755	Feed from L.P. filter to fuel pump	250
	Cooling feed from fuel pump to circulating pump	250
	Restrictor to front bearing	250
	Metering pump feed	250
	Two combustion chamber drain	250
	A-F.R.C. unit to circulating pump and valve group unit	1,700
Note . . .		
<i>This rig is provided with a high pressure hydraulic shut-off valve to enable the A-F.R.C. unit to circulating pump and valve group unit pipe to be isolated from the remainder and tested at nearly seven times the pressure.</i>		
T78758	Nine manifold spill	1,270
	One manifold spill connection	1,270

Blade peening fixture

Turbine blade peening fixture T76570 consists of a heavy base provided with a turntable and a mounting carrying a pair of Broomwade pneumatic hammers. A range of turbine disc adapters for standard and undersized discs is provided to fit the turntable; two bolts secure the turbine disc to the adapter. A pair of handed anvils supports the blades underneath, and a locking clamp is pressed down on the disc between the two blades being peened; in addition, two steady bolts assist in supporting the disc during peening operations. Two steel feeler strips clamped to a block locate the disc in the correct position for peening. The instructions for the setting up and the operation of this fixture is given in Chapter 28C.

Locating block

Locating block T76571 is provided with two steel feeler strips (fig. 41) which engage in the

gaps between the blade platforms and acts as an indexing device to ensure that the blade roots are positioned correctly for peening.

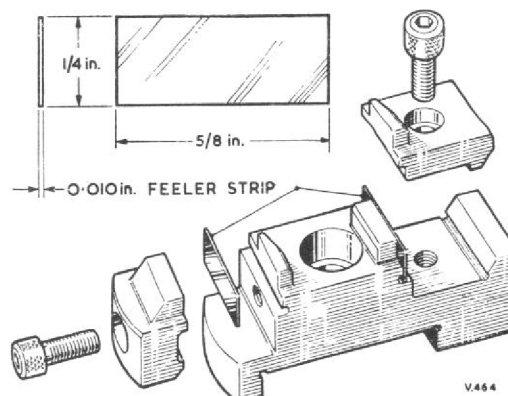


Fig. 41. Locating block T76571 showing renewable feeler strips

Blade extracting fixture

Turbine blade extracting fixture T78723 consists basically of a heavy base with a turntable and a mounting which houses a punch shaped to conform to the fir-tree form of the blade roots (fig. 42). A range of disc adapters for standard and undersized discs is provided to fit the turntable. An adjustable block supports the disc when a blade is extracted; the disc is secured to the adapter by two bolts. The fixture is used in conjunction with a Hare type P.O. hydraulic press; the ram of the press is coupled to the punch by punch holder T77380. The setting up and operation of this fixture is described and illustrated in Chapter 28C.

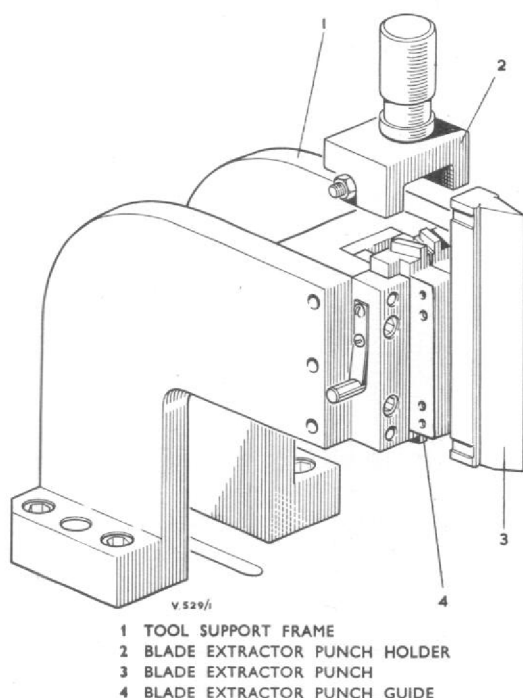


Fig. 42. Blade extractor punch, tool holder and guide

Motoring-over rig

The motoring-over rig is used to run-in all the accessory drives when assembled to the air-intake, and to test the functioning of the oil system. It consists basically of a rugged channel girder and angle iron structure having a 12½ h.p. electric motor with the necessary starter, switch gear, isolator, and gearbox to drive the accessory gears. The speed of the motor can be regulated by means of a wheel type control handle at the front of the rig. A Varley pump, Vokes filter and Heatrae heater is incorporated in the oil system.

An instrument panel mounted on the left hand side facing the front includes the following instruments:—

- Top left ... Rear bearing oil pressure gauge
- Top right ... Front bearing oil pressure gauge

- Centre left ... Tachometer
- Centre right ... Topwheel case oil pressure gauge
- Bottom left ... Oil temperature gauge
- Bottom right ... Bottom wheelcase or sump oil pressure gauge

Between the two bearing pressure gauges at the top of the panel, two needle valves controlling the oil supply to the gauges are positioned, one above the other. Between the tachometer and the top wheelcase oil pressure gauge, two small pipes supply oil from the rear bearing metering pump and the front bearing metering pump if the latter is fitted; test tubes graduated in c.c. beneath these pipes collect and measure the capacity of the oil flow when the needle valves are opened.

All the necessary pipes and adapters are provided with the rig and an adapter mounting ring for the type and mark of engine is also supplied. All instruments and pipes are clearly indicated by name plates. The use of the rig is described and illustrated in Chapter 33B.

Stud extractor

Due to the effort required and the risk of damage when removing ½ in. B.S.F. studs from the pivot and the centre shaft faces of the impeller, the normal methods of stud extraction are impracticable; stud extractor T78154 (fig. 43) should therefore be used for this purpose.

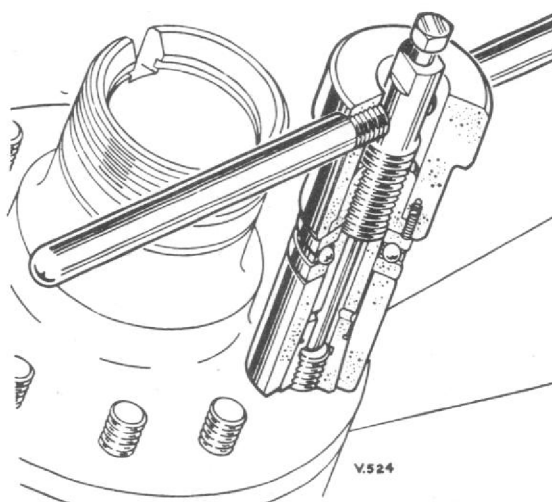


Fig. 43. Stud extractor T78154

Basically, this tool consists of a tapered collet screwed internally to suit the size of stud to be extracted, and an internally tapered bush to close the collet jaws. The collet has an external left-hand thread; a spider nut with a bush threaded to match screws over the collet. A ball bearing is inserted between the spider nut and the collet bush to take the thrust. A long bolt passes through the bore of the collet and bears on the end of the stud to be extracted.

BLADE PEENING FIXTURE

Changing the punches

To remove either peening punch lift the pneumatic hammer out of its location in the fixture, unscrew the lower spring from the hammer and remove the punch. To fit a punch reverse this procedure, but when refitting the hammer to the fixture ensure that the slot in the punch engages with the locating peg in the punch locating block and that the correct handed punch is fitted. New peening punches will conform to the required shape.

After peening the first few blades remove the punches and examine the imprint of the fir-tree root on the punch (A on fig. 44). The junction between the peening face A and the backing off B should lie close to the crest of the fir-tree root impression; if it is an appreciable distance from the crest there is a danger of the punch marking the turbine disc; to obviate this, the backing off B must be ground away at an angle of 20 deg. to A until the line between the faces A and B is nearly touching the crest of the fir-tree root impression. Similarly, the backing off C controls the number of serrations which are peened; if more than the specified 2 to 2½ serrations are being peened the backing C must be ground away at an angle of 45 deg. to A as necessary. All sharp edges must be smoothed out.

Changing the anvils

The anvils are in pairs and are handed; it is essential that they are kept in their correct locations as the disc bearing faces are ground with a step of a specified dimension and a clearance angle to locate the turbine blade root with the correct protrusion.

Unscrew the two anvil locating screws and wind back the anvil adjusting handle until the wedge is clear of the anvils. The anvils and their coil springs can then be withdrawn from below the anvil support block. To refit, reverse the procedure but ensure that the anvil locating screws engage with the slots in the anvils and that the latter are correctly positioned.

Routine servicing

The fixture should be cleaned, lubricated and adjusted as a matter of routine. Oil or grease as applicable should be applied periodically to all lubrication points. When not in use, measures to prevent corrosion and deterioration should be taken.

Apart from keeping the tool clean and adequately lubricated, servicing is confined to changing the steel feeler strips of the locating block; the method of doing this is described in Chapter 28C, Page 8. It is recommended that a little penetrating oil is put in each pneumatic gun to prevent corrosion and seizure due to the effect

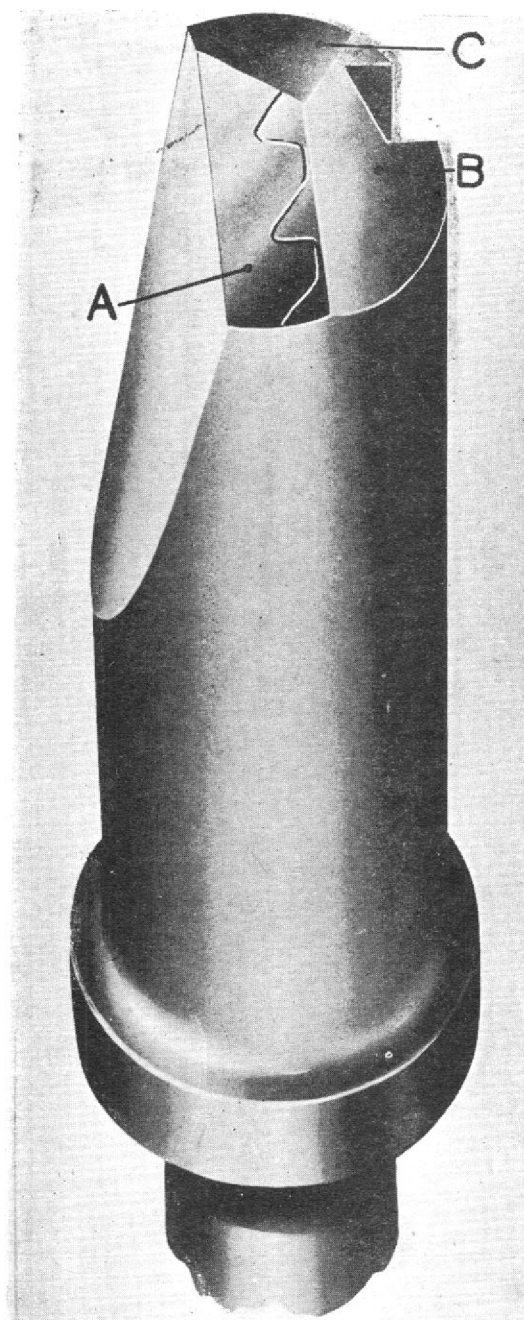


Fig. 44. Peening punch showing fir-tree impression

of moisture. Punches, anvils and disc locating blocks are function tested before leaving the manufacturer and they must not be separated from the fixture.

BLADE EXTRACTING FIXTURE

Changing the punch

To change the punch, slide up the punch guide clear of the mounting. The punch can then be drawn forward free of the two screws which locate in the grooves machined in both sides of the punch. To replace the punch reverse the procedure.

Routine servicing

The fixture should be cleaned, lubricated and adjusted as a matter of routine. Oil or grease as

applicable should be applied periodically to all lubrication points. When not in use, measures to prevent corrosion and deterioration should be taken. Apart from keeping the tool clean and adequately lubricated, servicing is confined to changing the punch.

MOTORING-OVER RIG

Routine servicing

The electrical apparatus should be kept clean and periodical servicing carried out. All instru-

ments should be calibrated against master instruments at regular intervals to ensure that they register correctly. Oil or grease as applicable should be applied periodically to all lubrication points. When not in use, measures to prevent corrosion and deterioration should be taken.

STUD EXTRACTOR

Routine servicing

Servicing consists of normal cleaning after use, and the application of rust preventive.

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